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ABSTRACT

This document contains the materials necessary to teach four instructional units on welding that are designed to prepare learners for entry-level employment. The following instructional units are presented: (1) welding materials; (2) welding tools; (3) welding layout and basic skills; and (4) oxyacetylene cutting. The document begins with a copy of the Introduction to Welding Competency Profile, on which the trainee's progress toward meeting instructional objectives can be recorded. A short chapter that explains how the document should be used precedes the instructional materials. Instructional materials for each unit include some or all of the following elements: (1) performance objectives; (2) suggested activities; (3) "must know" content, essential for meeting the cognitive objectives of the unit; (4) job sheets; (5) tests; (6) answers to tests; and (7) transparency masters. (CML)

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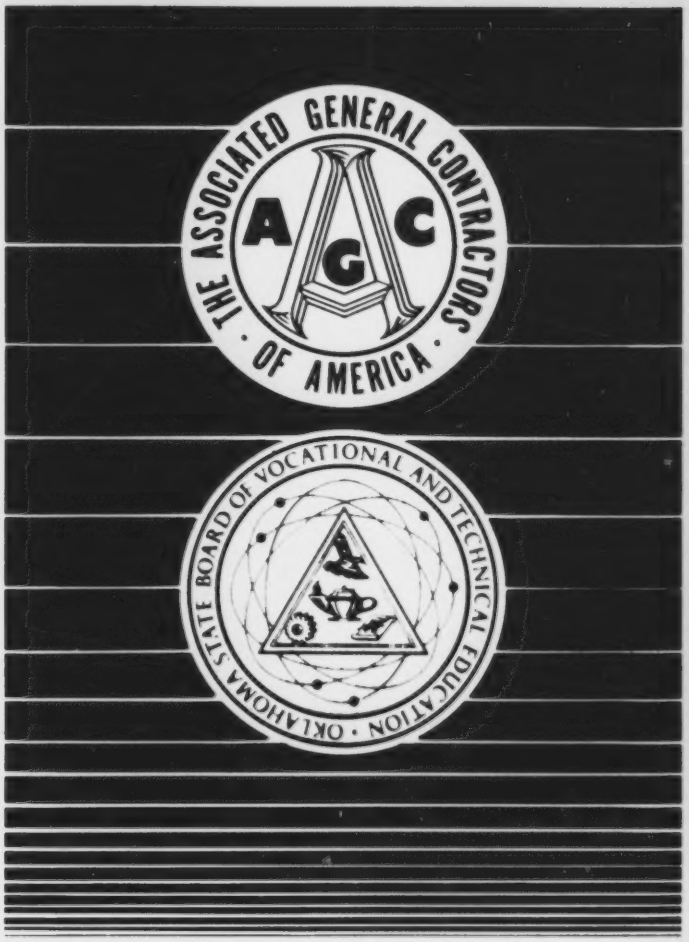
The Associated General Contractors of America



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Introduction to Welding

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Introduction to Construction Series

instructor edition

89-006594

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INTRODUCTION TO WELDING
COMPETENCY PROFILE

Student: _____ Soc. Sec. No.: ___ – ___ – _____
Last First MI

_____ Grade 9 10 11 12 Adult _____
PROGRAM SCHOOL

_____ _____ _____
INSTRUCTOR SCHOOL ADDRESS PHONE

_____ _____ _____
STUDENT'S HOME ADDRESS DATE OF BIRTH PHONE

_____

_____ _____ _____
STUDENT'S EMPLOYER ADDRESS PHONE

_____

_____ _____
CONTACT IN CASE OF EMERGENCY: PHONE

_____
ADDRESS

_____
OR

_____ _____
ADDRESS PHONE

The above information can be used for school records and/or to ensure safety of students. This confidential information is not to be released to employers or to the general public.

ON-JOB TRAINING/WORK EXPERIENCE

DURATION OF EMPLOYMENT	JOB TITLE	EMPLOYER	SUPERVISOR'S NAME	ADDRESS OF EMPLOYER	PHONE

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SPECIFIC JOB COMPETENCIES

Directions Evaluate the trainee using the rating scale below and check the appropriate number to indicate the degree of competency achieved. The numerical ratings of 4, 3, 2, 1, and 0 are not intended to represent the traditional school grading system of A, B, C, D, and F. The descriptions associated with each of the numbers focus on level of student performance for each of the tasks listed below. The written test score line is provided for optional teacher use. It may not be applicable in all cases. "NA" is an appropriate entry in such instances.

Rating Scale
4 — Skilled — can perform independently with no additional training.
3 — Moderately Skilled — has performed independently during training program, limited additional training may be required.
2 — Limited Practice — has practiced during training program, additional training is required to develop skill.
1 — Exposure Only — general information provided with no practice time, close supervision needed and additional training required.
0 — No Exposure — no information or practice provided during training program, complete training required.

4 3 2 1 0
☐☐☐☐☐ *Welding Materials*
☐☐☐☐☐ 1. _____

WRITTEN TEST SCORE _____

4 3 2 1 0
☐☐☐☐☐ *Welding Tools*
☐☐☐☐☐ 1. _____

WRITTEN TEST SCORE _____

4 3 2 1 0
☐☐☐☐☐ *Welding Layout and Basic Skills*
☐☐☐☐☐ 1. Start, stop, and restart a bead
☐☐☐☐☐ 2. Construct a pad weld
☐☐☐☐☐ 3. Construct a butt weld
☐☐☐☐☐ 4. _____

WRITTEN TEST SCORE _____

4 3 2 1 0
☐☐☐☐☐ *Oxyacetylene Cutting*
☐☐☐☐☐ 1. Set up equipment for oxyacetylene cutting
☐☐☐☐☐ 2. Turn on, light, adjust to a neutral flame, and turn off oxyacetylene cutting equipment
☐☐☐☐☐ 3. Cut mild steel at a 90-degree angle, stop, and restart the cut
☐☐☐☐☐ 4. Cut round stock
☐☐☐☐☐ 5. Cut cable
☐☐☐☐☐ 6. _____

WRITTEN TEST SCORE _____

Use of This Document

This document can be used to record information about the student and the skills mastered by the student. This information is useful in documenting student progress during the training program and to provide information about the student's qualifications to potential employers and for entry into advanced training programs. Instructors using AGC-CIMC instructional materials are authorized to reproduce this document as required for use in their training programs.

INTRODUCTION TO WELDING

Developed as a Cooperative Project by
Manpower and Training Committee
The Associated General Contractors of America
and
Curriculum and Instructional Materials Center
Oklahoma State Department of Vocational and Technical Education

89-006594

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FOREWORD

In 1985, The Associated General Contractors of America (AGC) met with representatives of the Oklahoma Curriculum and Instructional Materials Center (CIMC) to discuss the possibilities of developing, as a cooperative project, a course of instruction designed for training individuals who choose to seriously explore careers in construction.

This publication is the result of those original discussions and close coordination among general contractors and vocational educators. This series represents a conscious effort to coordinate the practical experience of personnel in the construction industry with the best instructional methods of those in the field of vocational education.

Although this series reflects a systematic approach to instructional materials development and the latest in educational technology innovations, the information in *Introduction to Welding* should be adapted and modified to coincide with local conditions.

Roy Peters, Jr., Director
Oklahoma State Department of
Vocational and Technical Education

William K. Healy, Chairman
Manpower and Training Committee
The Associated General Contractors
of America

PREFACE

For many years, The Associated General Contractors of America (AGC) has recognized the need for providing quality competency-based instructional materials for the construction industry. AGC and the Oklahoma State Department of Vocational and Technical Education have met this challenge by providing nationally recognized curriculum and services since 1972. In 1986 AGC and Oklahoma's Curriculum and Instructional Materials Center (CIMC) determined a significant need for a series that would address training needs of open-shop contractors, preapprenticeship programs, multi-craft high school programs, technology education programs, CVET, and cooperative education programs. The Introduction to Construction Series was designed with the flexible training requirements of these groups in mind.

The Introduction to Construction Series begins with *Fundamentals of Construction* and progresses to twelve spin-off specialty publications. *Fundamentals of Construction* covers basic knowledge necessary for all individuals in construction. Each specialty area covers basic skills necessary for entry-level employment. Both vocational education and the construction industry offer more advanced courses in each specialty area and should be considered by individuals wishing to establish careers in the industry. Competency profiles (provided in the teacher edition) for the Introduction to Construction Series articulate with several more advanced AGC/CIMC publications as well as publications developed by the Mid-America Vocational Curriculum Consortium (MAVCC).

Publications in this series include:

- Introduction to Bricklaying
- Introduction to Carpentry
- Introduction to Concrete Masonry
- Introduction to Concrete Reinforcing
- Introduction to Electricity
- Introduction to Plumbing
- Introduction to Heating, Ventilation, and Air Conditioning
- Introduction to Sheet Metal
- Introduction to Roofing
- Introduction to Drywall
- Introduction to Insulation
- Introduction to Welding

USE OF THIS PUBLICATION

Instructional Units

Inroduction to Welding contains four instructional units. A standard format was established in 1970 for development of instructional materials for all Oklahoma vocational teachers. This format includes eight basic components that form a unit of instruction: performance objectives, suggested activities for the teacher, information sheets, assignment sheets, job sheets, transparency masters and supplements, tests, and answers to tests and assignment sheets. Depending on the specific objectives, there may or may not be transparency masters, supplements, assignment sheets, or job sheets included in the unit of instruction.

All of the unit components "zero in" on measurable and observable learning outcomes. Teachers are encouraged to supplement, personalize, localize, and motivate with these materials in order to develop a complete teaching/learning process.

Units of instruction are designed for use in more than one lesson or class period of instruction. Careful study of each unit of instruction by the teacher will help him or her determine the following

- Amount of material that can be covered in each class period
- Skills that must be demonstrated
  - Supplies and equipment needed
  - Amount of practice needed
  - Amount of class time needed for demonstrations
- Supplementary materials, such as pamphlets and filmstrips, that must be ordered
- Resource people to contact

Performance Objectives (white pages)

Each unit of instruction is based on the performance needed for successful employment in an occupational area. Performance objectives are stated in two forms: unit objectives, stating the subject matter to be covered in a unit of instruction; and specific objectives, stating the performance necessary to reach the unit objective. Since the objectives of the unit provide direction for the teaching/learning process, it is important that teachers and students have a common understanding of the intent of the objectives.

The objective sheet should be given to students and referred to throughout the teaching/learning process. This will help answer any questions concerning performance requirements for each instructional unit. The objectives can also help determine teaching strategies and instructional methods. Prepare for each unit by deciding how each objective can best be taught.

The objective sheet may also be used as a quick pretest to determine students' prior knowledge and to determine whether further study or activities are necessary. Teachers should feel free to modify, delete, or add objectives in order to meet the needs of the students and community. When changes in objectives are made, the teacher should remember to supply the needed information, assignment and/or job sheets, and criterion test items.

Suggested Activities (pink pages)

Suggested activities are included only in teacher materials. The suggested activities pages include an outline of the unit contents and an instructor's guide designed to assist teachers in planning their presentation of the unit. The instructor's guide provides suggestions for delivery and/or presentation during the instructional process. Read the suggested activities before teaching the units so that supplemental materials can be obtained, audiovisual materials prepared, and outside resources contacted. Duties of the teacher will vary according to the particular unit.

The references that are listed in the suggested activities are ones used in the development of each unit. They may be used by the teacher to supplement her or his knowledge of the subject area or to help students with particular interests or occupational objectives in the area covered.

All references in this publication were known to exist at the time of the writing of this publication. AGC/CIMC assumes no responsibility to provide these materials and cannot ensure the availability of these materials as individual vendors, manufacturers, and publishers may discontinue these products at any time.

The suggested activities section of the unit also includes supplements and transparency masters. Each of these components provides information in a special way. Supplements may consist of motivational materials, review or practice materials such as crossword puzzles and self-tests, or charts and reference materials. Supplements are designed to be copied and distributed to individual class members or to the class as a whole. Suggestions for their use are included in the instructor's guide. Transparencies direct the class' attention to the topic of discussion. Transparencies may present new information, or they may reinforce information presented in the information sheet. They are particularly effective when identification or analysis is necessary. Make transparencies and place them in the notebook where they will be immediately available for use.

Information Sheet (green pages)

The information sheet provides "must know" content essential for meeting the cognitive (knowledge level) objectives of the unit. The information is written in a topical-outline form and is keyed to the specific objectives.

Teachers will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. The information sheet may also be used for coordination activities and advisory committees.

Students should read the information sheet before the information is discussed in class. Space is provided in margins for students and teachers to add notes that supplement, localize, personalize, or provide motivation for each unit.

Assignment Sheets (brown pages)

Assignment sheets give students a chance at problem solving, self-assessment, and/or practical experience. They assist students in the application of knowledges that are necessary prerequisites to skill development. Assignment sheets may be given to the student for completion in class or may be used for homework assignments. Answer sheets are provided

when appropriate and can be used by the student and/or teacher for checking student progress. The scores of those assignment sheets listed in the specific objectives should be averaged with the unit test score, as the skills addressed in these assignment sheets are considered necessary in meeting the unit objective.

Job Sheets (blue pages)

Job sheets are another important segment of a unit of instruction. The job sheets provide a list of equipment, tools, and materials needed to complete a manipulative or psychomotor skill. They describe a step-by-step procedure needed to complete each task or job. Diagrams, photographs, and illustrations are provided to assist students in achieving the skill.

The teacher should demonstrate to students the procedures outlined in each job sheet. Furthermore, the teacher needs to localize the job sheet according to the equipment and supplies available in the local lab or shop situation. Job sheets also furnish potential employers with a picture of the skills being taught and the performances they might reasonably expect from a person who has had this vocational instruction.

Job sheet performance should be evaluated by the instructor and averaged with the unit test score, as the skills addressed in the job sheets are considered necessary in meeting the unit objective.

Tests (white pages)

Tests are included only in teacher materials. The test provides criterion-referenced evaluation of every objective listed in the unit of instruction. It is crucial to note that both paper/pencil and performance objectives must be evaluated.

It is recommended that the tests be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered. A selection of questions from the units covered may be used for final tests at the end of each term if desired. If objectives have been added, deleted, or modified, be sure to make the changes on the test.

The acceptable response on a unit test, 80 percent in most units, may be raised or lowered to fit the topic or students' ability levels. The percentage applies to the overall score, not to each question. The final unit grade should be obtained by using the paper/pencil score and evaluations of student demonstrations of the desired skills.

Answers to Test and Answers to Assignment Sheets (pink pages)

Answers to test and answers to assignment sheets are components designed to assist the teacher in evaluation of student performances.

Page Numbering

Each publication from the Curriculum and Instructional Materials Center (CIMC) is assigned a specific abbreviation. For example, *Introduction to Welding* has been abbreviated ITW. The units are then numbered consecutively within each section. An example of a page number is ITW-1. Since CIMC publications are loose-leaf, this system of page numbering was adopted so that pages from different manuals would not get mixed up.

Methods of Disseminating Material

For best results, provide student materials for each student. Student materials contain everything but the test, supplements, answers to assignment sheets, answers to test, and suggested activities.

Teaching Methods

It is a challenge to keep students motivated. Supplement the objectives by providing the "why," personal experiences, and current information. Prepare for each unit by deciding how each objective can best be taught. Allow students to become involved in preparing and planning.

Competency Profiles

Competency profiles are used to document student performance. The profile contains a list of the specific job competencies that a student should achieve prior to leaving the training program. A competency profile master is provided in the instructor edition of each publication. Duplicate the profile and distribute to students as required.

Other AGC/CIMC Publications: AGC/CIMC updates curriculum products on a continuing basis. For a free catalog describing other AGC products, call the AGC National office at 1-202-393-2040. Oklahoma instructors should call the CIMC at 1-800-522-5810, extension 589.

CORRECTIONS AND SUGGESTIONS

The Curriculum and Instructional Materials Center (CIMC) wants to provide vocational instructors and students with materials that are accurate and effective. Although the CIMC strives to maintain the highest standards of development and production, oversights occasionally do occur. If you find any errors in this or other CIMC publications, or have suggestions for improving their usefulness in vocational programs, please notify the CIMC staff. One easy way of pointing out errors is to make a photocopy of the affected page and to indicate the correction on the copy. You can mail the information to the CIMC, where it will be used to correct the publication before the materials are reprinted.

To ensure that the material is updated on a timely basis, it is important that you notify the CIMC of necessary corrections as soon as possible after discovering the error. Do not assume that someone else will notice the error and inform the CIMC; other users may be making the same assumption. Please send corrections and recommendations for improving this publication to the following address:

Coordinator of Curriculum Development
Curriculum and Instructional Materials Center
Oklahoma State Department of Vocational and
Technical Education
1500 West Seventh Avenue
Stillwater, Oklahoma 74074-4364

WELDING MATERIALS
UNIT I

UNIT OBJECTIVE

After completing this unit, the student should be able to identify standard metal shapes used in welding, match tests for metal identification to their correct procedures, and list situations when preheating is required. The student will show this ability by completing the unit test with a minimum score of 80 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match terms associated with welding materials to their correct definitions.
2. Distinguish between the basic categories of metals.
3. Match tests for metal identification with their correct procedures.
4. Identify standard metal shapes available for welding.
5. Match heat applications with their correct uses in weld quality control.
6. List situations when preheating is usually required.
7. Select from a list methods of preheating and postheating.
8. Match temperature-sensing devices with their correct uses.
9. Select from a list common sizes of electrodes used in arc welding.

WELDING MATERIALS
UNIT I

SUGGESTED ACTIVITIES

I. Unit contents

A. Objective sheet

B. Suggested activities

C. Transparency masters

1. TM #1 — Metal Melting Points and Other Temperatures

2. TM #2 — Heating Ranges for Ferrous Metals

D. Information sheet

E. Test

F. Answers to test

II. Instructor's guide

A. Review unit and plan presentation.

B. Obtain materials to supplement unit.

1. Samples of different types and shapes of metals

2. Samples of different types and sizes of electrodes

3. Catalogs from various steel and electrode manufacturers

4. Electrode selection wall chart and electrode guide books

(NOTE: Obtain from your local welding supplier.)

5. Films

a. *Arc Welding*. Color, 30 minutes, Association Films, 1971. Available from Association Films, 600 Grand Avenue, Richfield, New Jersey 07657.

(NOTE: This film explains major arc welding processes, required equipment, and progress made in the field. It is available to Oklahoma instructors on a free-loan basis from the Oklahoma State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center Film Library, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364. Out-of-state instructors must order from the address listed above.)

b. *Don't Push Your Luck*. Color, 12 minutes, Harvest Films, 1978. Available from Harvest Films, Inc., 309 Fifth Avenue, New York, New York 10016, 212/648-7950.

(NOTE: Bill Frank, the actual victim, recreates his blinding accident. He delivers to employees a powerful safety message on face and eye protection.)

6. Slide/cassette program — *There's Something in the Air*. Thirty slides with cassette, National Safety Council, n.d. Available from National Safety Council, P.O. Box 11933, Chicago, Illinois 60611, 312/527-4800.

(NOTE: This program tells workers how to protect themselves from contaminated air — fogs, mists, fumes, gases, smokes, sprays, and vapors that could be harmful to their lungs.)

7. Transparencies and competency profiles

(NOTE: A master of the competency profile for this book is provided at the front of the instructor edition. You may duplicate the profile and distribute it to students as needed.)

C. Check all welding equipment for proper condition and quantity: helmets, helmet lenses, safety glasses, and gloves.

D. Have students bring proper protective clothing to class prior to teaching unit; provide a storage place for the clothes.

E. Introduce unit by emphasizing proper safety procedures and the benefits of knowing how to weld.

- Stress the increased job opportunities that exist for workers who can weld and who really know metals and electrodes.
- Point out to the students how they can save money by being able to make their own repairs and complete projects which they would otherwise have to hire someone to do.
- Show film *Arc Welding*.

F. Provide students with objective sheet.

G. Discuss unit and specific objectives.

- Point out how the information in the unit will help the students learn the different categories of metals and their uses. The information will also help them to learn the different sizes of electrodes.

H. Provide students with information sheet.

I. Discuss information sheet.

SUGGESTED ACTIVITIES

1. Use Information Sheet, Section I, to discuss terms and definitions associated with welding materials.
   - Point out how knowing these terms and definitions will help students to better understand the unit.
   - Show students examples of terms when appropriate.
2. Use Information Sheet, Section II, to discuss basic categories of metals.
   - Show samples of various categories of metals; explain the differences to the students.
3. Use Information Sheet, Section III, to discuss tests for metal identification and their procedures.
   - Discuss the different tests and safety precautions that should be taken when demonstrating the test procedures.
   - Demonstrate the various tests.
   - Show films *Arc Welding* and *Don't Push Your Luck* and slide/cassette program *There's Something in the Air.*
   - Relate the films to the different tests being demonstrated and allow time for discussion of the film and cassette presentations.
   - Have students demonstrate procedures for the tests.
4. Use Information Sheet, Section IV, to discuss standard metal shapes available for welding.
   - Provide samples of each of the different shapes of metal for the students to see, feel, and examine.
   - Explain where and how each shape of metal may be used.
   - Have students provide other ideas of where these shapes of metals may be used.
5. Use Information Sheet, Sections V through VII, to discuss heat applications and their uses in weld quality control, situations where preheating is usually required, and methods used to preheat or postheat.
   - Explain to students that in order to become good welders they need to know where and when heat applications are required, the type of heat applications that should be used and the methods for use.
   - Discuss the different types of heat applications and their uses.
   - Discuss situations where preheating is usually required.
   - Discuss the methods used for preheating and postheating.

- Show students examples of the equipment used for preheating and postheating.

- Discuss overheating and heat ranges. Use Transparencies #1 and #2 to supplement your discussion.

6. Use Information Sheet, Section VIII, to discuss temperature-sensing devices and their uses.

   - Explain to the students that for mild steels preheating is not normally required; but, if temperature is below 50°F, preheat metal to about 100°F or higher if the plate thickness is over 1".

   - Explain to the students that for medium carbon steels preheat and interpass temperatures should be from 200°F to 400°F and postheat is recommended, especially on thicker sections.

   - Explain to the students that for high carbon steels preheat and interpass temperatures should be a minimum of 400°F and postheat is recommended, especially on thicker sections.

   - Provide samples of the various types of temperature-sensing devices, and allow the students to examine them; explain how they work.

   - Discuss and demonstrate how each of the devices should be used.

7. Use Information Sheet, Section IX, to discuss sizes of electrodes used in arc welding.

   - Discuss various sizes of electrodes. Show students examples of each size and allow students to examine them.

   - Point out the types of information that can be obtained from the electrode selection wall chart and the electrode pocket guide books.

   - Use an electrode handbook to discuss selection of electrodes; relate electrodes commonly used on the job to their uses.

   - Explain that on the electrode selection wall chart, different current settings are suggested for different thicknesses of metal and different electrode sizes.

   - Remind students to always think "SAFETY" when working around or with welding equipment.

J. Review unit.

K. Give test.

L. Critique test and discuss in class.

M. Reteach and retest if required.

SUGGESTED ACTIVITIES

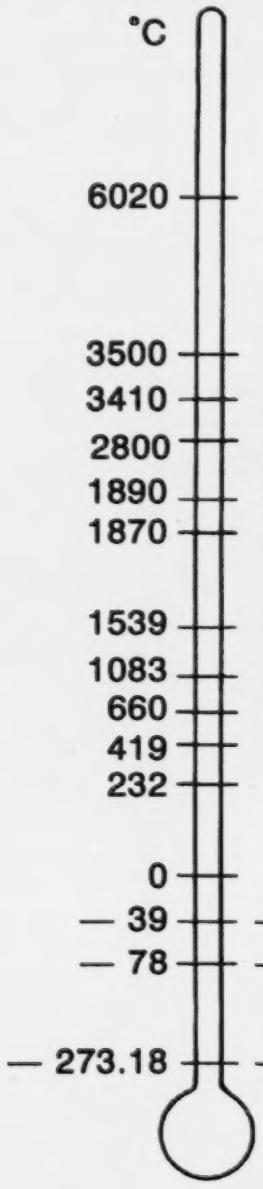
N. Complete appropriate sections of competency profile.

III. Unit references

A. Fortney, Clarence, and Mike Gregory. *Introduction to Welding*. Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, Inc., 1984.

B. Hendrix, Laborn J. "Bud." *Commercial Carpentry*. Stillwater, Oklahoma: State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center and The Associated General Contractors of America, 1986.

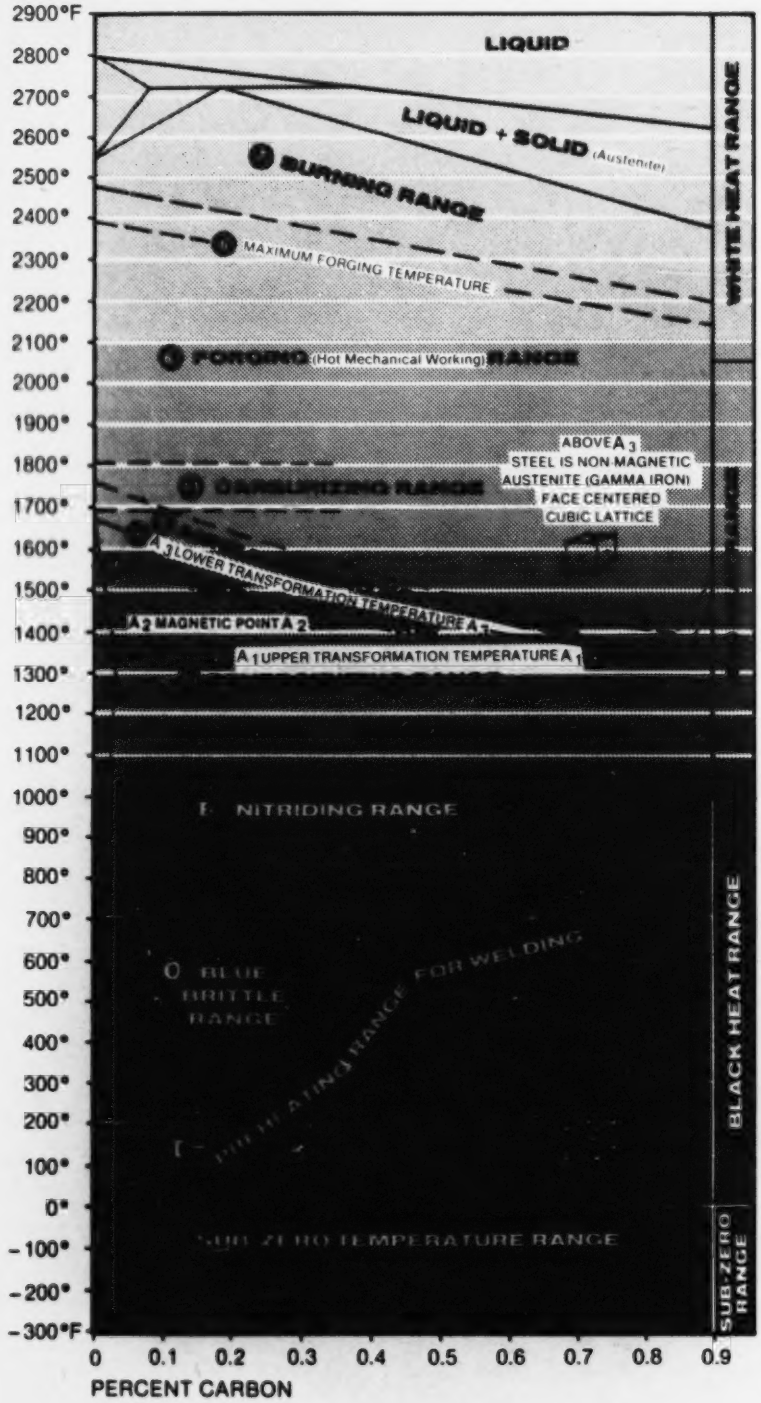
Metal Melting Points and Other Temperatures



°C	°F	
6020	10,900	Welding arc
3500	6330	Oxyacetylene flame
3410	6170	Tungsten melts
2800	5070	Oxyhydrogen flame
1890	3430	Chromium melts
1870	3360	Natural gas burner
1539	2802	Iron melts
1083	1981	Copper melts
660	1220	Aluminum melts
419	787	Zinc melts
232	449	Tin melts
0	32	Ice melts
— 39	— 38	Mercury melts
— 78	— 110	Dry ice vaporizes
— 273.18	— 459.72	Absolute zero

Courtesy Lincoln Electric Company

Heating Ranges for Ferrous Metals



WELDING MATERIALS
UNIT I

INFORMATION SHEET

I. Terms and definitions associated with welding materials

A. **Brazing** — Process of joining two metals together by heating the base metal to a dull red color and depositing a bead over the seam (joint) with a bronze filler rod, without melting the base metal

B. **Compatibility** — Two or more metals that have properties that can readily be welded

C. **Filler metal** — Metals added when brazing, welding, or soldering

D. **Interpass heating** — Application of heat to a base metal during a welding process

E. **Metallurgy** — Science of separating metals from their ores and smelting or refining them for use

F. **Postheating** — Application of heat to welding or a weldment after a welding or cutting operation to promote a slower cooling rate and relieve stresses in the base metal and the weldment

G. **Preheating** — Application of heat to a base metal before welding or cutting

H. **Soldering** — Process of joining soft metals together by melting a metal or metallic alloy and depositing a bead over the seam to unite the two pieces together

I. **Welding** — Process of joining two metals together by heating them with a torch or an electric arc with or without filler metal

J. **Weldment** — Assembly of two or more metal parts by welding

II. Basic categories of metals

A. Ferrous — Metals that contain iron as a major element

EXAMPLES: Low, mild, medium, and high carbon steels; cast iron

B. Nonferrous — Metals that contain no iron or extremely small amounts of iron

EXAMPLES: Aluminum, copper, zinc, lead, tin, nickel, silver, titanium, and gold

III. Tests for metal identification and their procedures

A. **Magnet** — A magnet will stick to ferritic alloys, but it will not stick to nonferritic alloys

B. **File** — Nonferrous metals can usually be filed easily, and ferrous metals are more difficult to file

C. **Spark** — Ferrous metals have definite spark patterns, and nonferrous metals have no spark patterns

D. **Chemical** — Certain chemicals or acids applied to metals cause different reactions

EXAMPLE: A weak solution of nitric acid or copper sulfate applied to stainless steel will remain clear, but will darken when applied to carbon steel.

E. **Appearance** — General surface appearance, color, and the presence of oxidation

EXAMPLE: Some metals exposed to weather will rust, others will tarnish, and others will remain free of oxidation.

F. **Sound** — When struck with a hammer, most metals have a characteristic ring or lack of it

EXAMPLE: Steel has a higher-pitched ring than cast iron.

G. **Chisel** — When chipped with a chisel, certain metals produce a continuous chip, others break up into small particles, and still others cannot be chipped

EXAMPLE: Low carbon steel chips easily and leaves a continuous chip, but cast iron is not easy to chip and breaks up into small chips.

IV. Standard metal shapes available for welding

A. Round bar

FIGURE 1

B. Half-round bar

FIGURE 2

INFORMATION SHEET

C. Oval bar

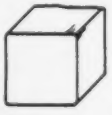
FIGURE 3

D. Half-oval bar

FIGURE 4

E. Square bar

FIGURE 5



F. Hexagon bar

FIGURE 6

G. Flat bar

FIGURE 7

H. H-beam

FIGURE 8

I. I-beam

FIGURE 9

J. Channel

FIGURE 10

K. Angle

FIGURE 11

L. Tee

FIGURE 12

INFORMATION SHEET

M. Zee

FIGURE 13

N. Flat sheet

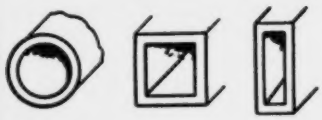
FIGURE 14

O. Flat plate

FIGURE 15

P. Tubing and pipe

FIGURE 16



Q. Rail

FIGURE 17

INFORMATION SHEET

V. Heat applications and their uses in weld quality control

A. **Preheat** — Heating a part before the welding process starts to help control cracking, to prevent stresses from shrinkage, and to promote a slower cooling rate to prevent excessive hardening

B. **Interpass heat** — Heating between welding passes to maintain the preheat temperature

(NOTE: The welding process itself will usually provide sufficient interpass heat. However, on large assemblies, heating with a torch between passes is required to maintain proper welding temperatures.)

C. **Postheat** — Heating a part after the welding process and allowing it to cool slowly to promote stress relief in the weldment and the base metal

VI. Situations when preheating is usually required

A. When large or bulky parts are being welded, or when parts being welded have a complicated shape

B. When the atmospheric temperature is cold or the temperature of the parts is cold

C. When the carbon or alloy content of steel is high

D. When the welding speed is fast

E. When small-diameter welding rods are used

VII. Methods of preheating and postheating

A. Furnaces

B. Electrical strip heaters clamped parallel to joints about 6" from the seam

C. Acetylene, propane, or oil torches used singly or in banks of two or more

D. Torch heating using natural gas with compressed air using a single-orifice heating tip the same size that would be used to oxyacetylene weld the joint

(NOTE: This method is used frequently in shop work because it gives a hot flame that burns clean and helps avoid contaminating the weld zone.)

E. Torch heating using multiflame heads or rosebuds

VIII. Temperature-sensing devices and their uses

A. **Pyrometers** — Portable thermometers specifically designed to measure surface heat

B. **Thermocouples** — Temperature-sensing devices that may be attached to the work, but more often used in heating ovens and postweld heat treatment

INFORMATION SHEET

C. **Crayons and pellets** — Temperature-sensing devices that melt suddenly when the work reaches a specific temperature

(NOTE: Crayons are usually color-coded for specific temperatures, and are frequently used in pairs to indicate a low and high range of heating so desired temperatures can be more accurately determined.)

IX. Common sizes of electrodes used in arc welding

(NOTE: Electrodes range in sizes from 1/16 to 5/8 inch.)

A. 3/32 inch

B. 1/8 inch

C. 5/32 inch

D. 3/16 inch

WELDING MATERIALS
UNIT I

TEST

NAME _____ SCORE _____

1. Match terms associated with welding materials to their correct definitions. Write the correct numbers in the blanks.

_____a. Process of joining two metals together by heating them with a torch or an electric arc with or without filler metal

_____b. Metals added when brazing, welding, or soldering

_____c. Process of joining two metals together by heating the base metal to a dull red color and depositing a bead over the seam (joint) with a bronze filler rod, without melting the base metal

_____d. Process of joining soft metals together by melting a metal or metallic alloy and depositing a bead over the seam to unite the two pieces together

_____e. Application of heat to a base metal before welding or cutting

_____f. Application of heat to a base metal during a welding process

_____g. Application of heat to welding or a weldment after a welding or cutting operation to promote a slower cooling rate and relieve stresses in the base metal and the weldment

_____h. Assembly of two or more metal parts by welding

_____i. Two or more metals that have properties that can readily be welded

_____j. Science of separating metals from their ores and smelting or refining them for use

1. Soldering
2. Interpass heating
3. Weldment
4. Welding
5. Metallurgy
6. Preheating
7. Brazing
8. Compatibility
9. Postheating
10. Filler metal

TEST

2. Distinguish between the basic categories of metals. Write an "F" in the blank before the category that refers to ferrous metals.

_____a. Metals that contain no iron or extremely small amounts of iron

_____b. Metals that contain iron as a major element

3. Match tests for metal identification with their correct procedures. Write the correct numbers in the blanks.

_____a. This device will stick to ferritic alloys, but it will not stick to nonferritic alloys

_____b. Nonferrous metals can usually be worked easily, and ferrous metals are more difficult to work

_____c. Ferrous metals have definite patterns and nonferrous metals have no patterns

_____d. Certain agents or acids applied to metals cause different reactions

_____e. General surface appearance, color, and the presence of oxidation

_____f. When struck with a hammer, most metals have a characteristic ring or lack of it

_____g. When chipped, certain metals produce a continuous chip, others break up into small particles, and others cannot be chipped

1. Spark
2. Chisel
3. Sound
4. Magnet
5. File
6. Chemical
7. Appearance

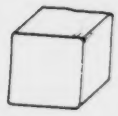
4. Identify the following standard metal shapes available for welding. Write the correct names in the blanks.

a. _____ b. _____ c. _____

TEST

d. _____

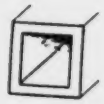
e. _____



f. _____

g. _____

h. _____



i. _____

j. _____

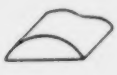
k. _____

l. _____

m. _____

n. _____

o. _____



p. _____

q. _____

TEST

5. Match heat applications to their correct uses in weld quality control. Write the correct numbers in the blanks.

_____a. Heating between welding passes to maintain the preheat temperature

_____b. Heating a part after the welding process and allowing it to cool slowly to promote stress relief in the weldment and the base metal

_____c. Heating a part before the welding process starts to help control cracking, to prevent stresses from shrinkage, and to promote a slower cooling rate to prevent excessive hardening

1. Postheat
2. Preheat
3. Interpass heat

6. List three situations when preheating is usually required.

a. _____

_____

b. _____

_____

c. _____

_____

7. Select from the following list methods of preheating and postheating. Write an "X" in the blanks before the correct methods.

_____a. Torch heating using natural gas with compressed air using a single-orifice heating tip the same size that would be used to oxyacetylene weld the joint

_____b. Electrical strip heaters clamped directly over the seam

_____c. Torch heating using multiflame heads or rosebuds

_____d. Acetylene, propane, or oil torches used singly or in banks of two or more

_____e. Furnaces

TEST

8. Match the following temperature-sensing devices to their correct uses. Write the correct numbers in the blanks.

_____a. Temperature-sensing devices that may be attached to the work, but more often used in heating ovens and postweld heat treatment	1. Thermocouples
_____b. Temperature-sensing devices that melt suddenly when the work reaches a specific temperature	2. Crayons and pellets
_____c. Portable thermometers specifically designed to measure surface heat	3. Pyrometers

9. Select from the following list common sizes of electrodes used in arc welding. Write an "X" in the blanks before the correct sizes.

_____a. 3/32 inch

_____b. 11/16 inch

_____c. 3/16 inch

_____d. 7/8 inch

WELDING MATERIALS
UNIT I

ANSWERS TO TEST

1. a. 4 d. 1 g. 9 j. 5
   b. 10 e. 6 h. 3
   c. 7 f. 2 i. 8

2. b

3. a. 4 c. 1 e. 7 g. 2
   b. 5 d. 6 f. 3

4. a. Round bar
   b. Angle
   c. Flat bar
   d. Rail
   e. Tee
   f. Square bar
   g. Half-round bar
   h. Channel
   i. Tubing and pipe
   j. I-beam
   k. Hexagon bar
   l. Flat sheet
   m. H-beam
   n. Oval bar
   o. Zee
   p. Half-oval bar
   q. Flat plate

5. a. 3 b. 1 c. 2

6. Any three of the following

   a. When large or bulky parts are being welded, or when parts being welded have a complicated shape
   b. When the atmospheric temperature is cold or the temperature of the parts is cold
   c. When the carbon or alloy content of steel is high
   d. When the welding speed is fast
   e. When small-diameter welding rods are used

7. a, c, d, e

8. a. 1 b. 2 c. 3

9. a, c

WELDING TOOLS
UNIT II

UNIT OBJECTIVE

After completing this unit, the student should be able to identify various tools used by welders and should be able to match various tools to their uses. The student should also be able to state guidelines for safe use and care of welding tools and general safety rules pertaining to welding tools. The student will show this ability by completing the unit test with a minimum score of 80 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match terms associated with welding tools to their correct definitions.
2. State the meanings of abbreviations associated with welding.
3. Name types of arc welding machines.
4. Select from a list common equipment used in arc welding.
5. Match types of hammers with their characteristics and uses.
6. Match types of chisels and punches with their uses.
7. Select from a list statements concerning files and their uses and basic shapes and cuts.
8. Select from a list statements concerning wire brushes and their shapes and uses.
9. Match holding and anchoring tools with their characteristics and uses.
10. Match measuring instruments with their characteristics and uses.
11. Match squares with their characteristics and uses.
12. Match types of hand levels with their characteristics and uses.
13. Match types of wrenches with their uses.
14. Match types of cutting and shaping tools with their uses.
15. Identify portable power tools used by welders.
16. Identify stationary power tools used by welders.
17. State guidelines for safe use and care of hand tools.

OBJECTIVE SHEET

18. State general safety rules pertaining to power tools and equipment.

19. State guidelines for proper care of power tools and equipment.

WELDING TOOLS
UNIT II

SUGGESTED ACTIVITIES

I. Unit contents

A. Objective sheet

B. Suggested activities

C. Information sheet

D. Test

E. Answers to test

II. Instructor's guide

A. Review unit and plan presentation.

B. Obtain materials to supplement unit.

1. Tool catalogs

(NOTE: Obtain several tool catalogs and display for students to review.)

2. Competency profile

(NOTE: A master of the competency profile for this book is provided at the front of the instructor edition. You may duplicate the profile and distribute it to students as needed.)

C. Introduce unit to students emphasizing the importance of safety practices and benefits of knowing how to use tools properly and learning how to weld properly.

- Ask students to review tool catalogs; discuss welding equipment, hand tools, and power tools. Point out the importance of buying good grades of tools. Tell students that quality, not price, should be their main concern when purchasing tools.

D. Provide students with objective sheet.

E. Discuss unit and specific objectives emphasizing the care and safe use of tools and equipment.

F. Provide students with information sheet.

G. Discuss information sheet.

SUGGESTED ACTIVITIES

1. Use Information Sheet, Section I, to discuss terms and definitions associated with welding tools.

   - Have students review terms.
   - Discuss, demonstrate and show examples of appropriate terms that may be unfamiliar to students.

2. Use Information Sheet, Section II, to discuss abbreviations associated with welding.

   - Develop a set of flash cards containing the various abbreviations. Have students use the cards in teams, or show the class the cards and have individuals give you the correct meanings.

3. Use Information Sheet, Section III, to discuss types of arc welding machines.

   - Take students on a tour to a shop to view the various types of welding machines.
   - Point out that welding on AC and DC machines using a stick electrode is referred to as "shielded metal arc welding" (SMAW); welding on a TIG machine is referred to as "gas tungsten arc welding" (GTAW); and welding on a MIG machine is referred to as "gas metal arc welding" (GMAW).
   - Give examples of the uses for each kind of welding machine.
   - Invite a local supplier to discuss kinds of welding machines and their uses.

4. Use Information Sheet, Section IV, to discuss common arc welding equipment.

   - Take students to the shop to show them the components that make up the arc welding equipment.
   - Explain to students what to look for when checking equipment to make sure that it is in good condition.
   - Demonstrate how to adjust helmets and change lenses.

5. Use Information Sheet, Section V, to discuss types of hammers and their characteristics and uses.

   - Display a sample of each type of hammer discussed in this section of the information sheet. Discuss the proper use of each hammer and allow students to handle hammers.

SUGGESTED ACTIVITIES

- Tell students to use the correct hammer for the job for which it was designed.

- Demonstrate the proper swing of a heavy hammer and precautions to take when using this hammer.

- Demonstrate the proper use of chipping hammers and the safety precautions, such as goggles and proper clothing. Show them what happens when chipping slag from a piece of hot metal.

6. Use Information Sheet, Section VI, to discuss types of chisels and punches and their uses.

   - Display a sample of each type of chisel and punch discussed in this section of the information sheet. Discuss uses of each chisel and punch, and allow students to examine them.

   - Caution students to wear eye protection when using chisels and punches.

   - Caution students against using chisels and punches that have mushroomed heads.

7. Use Information Sheet, Section VII, to discuss files, their uses, basic shapes and different cuts.

   - Display a sample of each type of file discussed in this section of the information sheet. Discuss uses of the different shaped files. Discuss the use of files in general. Discuss the basic file cuts.

   - Demonstrate how to attach handle to file and then demonstrate how to use the card file. Caution students not to use a file without a handle.

   - Allow students to handle each file and explain its use.

   - Allow students to demonstrate how to attach file handle and then demonstrate how to use the file card.

8. Use Information Sheet, Section VIII, to discuss types of wire brushes and their uses.

   - Display samples of various types of wire brushes. Discuss use of each wire brush and allow the students to examine them.

   - Caution students to wear eye protection when working with wire brushes.

SUGGESTED ACTIVITIES

9. Use Information Sheet, Section IX, to discuss holding and anchoring tools and their characteristics and uses.

   - Display a sample of each anchoring tool in this section of the information sheet. Discuss use of each of these tools and allow students to examine each tool.

   - Demonstrate the use of each anchoring tool and point out the benefits of having these tools tc help hold materials until and during the welding process.

10. Use Information Sheet, Section X, to discuss measuring instruments and their characteristics and uses.

    - Display a sample of each of the measuring instruments discussed in this section of the information sheet. Discuss use of each instrument and allow students to examine these instruments.

    - Stress the importance of proper care of measuring instruments and how improper care may cause inaccurate measurements, especially delicate instruments such as dial calipers and micrometers.

11. Use Information Sheet, Section XI, to discuss types of squares and their characteristics and uses.

    - Display a sample of each type of square discussed in this section of the information sheet. Discuss use of each square and allow students to examine the square.

    - Demonstrate the use of each square.

    - Caution students about careful handling of squares as damaged squares would mean inaccurate layout of materials and areas.

12. Use Information Sheet, Section XII, to discuss types of hand levels and their characteristics and uses.

    - Stress that leveling instruments are precision instruments that must be handled carefully—an instrument that has been dropped or treated roughly may be inaccurate.

    - Explain to students that levels should be checked frequently.

    - Demonstrate to students the proper method of checking levels.

      (NOTE: Job Sheet #4, Section C, Unit I in *Fundamentals of Carpentry* will show you how to check levels.)

SUGGESTED ACTIVITIES

13. Use Information Sheet, Section XIII, to discuss types of wrenches and their uses.

    - Display a sample of each type of wrench discussed in this section of the information sheet. Discuss proper use of wrenches and allow students to examine wrenches.
    - Remind students to use the correct wrench for the job for which it was designed.

14. Use Information Sheet, Section XIV, to discuss types of cutting and shaping tools and their uses.

    - Display a sample of the cutting and shaping tools discussed in this section of the information sheet. Discuss proper use of these tools.
    - Demonstrate proper use of these tools and then have the students demonstrate the proper use of each of these tools.

15. Use Information Sheet, Sections XV and XVI, to discuss power tools used by welders.

    - Introduce these units by emphasizing the convenience of power tools while stressing the fact that using power tools places an even greater responsibility on the student to be careful.
    - Tour the shop area, pointing out tools that the students will be learning to use and demonstrate uses of these tools.
    - Have students complete training program offered by manufacturers of power-actuated tools.

      (NOTE: No one, student or instructor, should be allowed to operate a power-actuated tool until he or she has been trained, certified, and issued a qualified operator's card.)

    - Display posters of safety rules for each tool in your shop.

16. Use Information Sheet, Section XVII, to discuss guidelines for care and safe use of hand tools.

    - Have students explain details of accidents they know of when someone used hand tools improperly.
    - Discuss newspaper clippings of case studies that relate to safe use of hand tools.
    - Demonstrate to students how to clean and store hand tools properly.
    - Explain your policy for replacement and repair of damaged tools.
    - Outline your tool-management policy for your shop.

SUGGESTED ACTIVITIES

17. Use Information Sheet, Sections XVIII and XIX, to discuss general safety rules and guidelines for proper care of power tools and equipment.

    - Demonstrate the proper care of tools in general.
    - Display examples of tools that have been improperly cared for or abused.
    - Discuss the safety, care, and use of each tool in accordance with your plan of presentation.

      (NOTE: We recommend that you present material for a particular tool and require the student to correctly answer all the questions regarding that tool before allowing the student to use that particular tool.)

    - Review information sheet and then have each student demonstrate correct operation of power tools, using other students to critique the performances.

H. Give test.

I. Critique test and discuss in class.

J. Reteach and retest as necessary.

K. Complete appropriate section of competency profile.

III. Unit references

A. Fortney, Clarence and Gregory, Mike. *Introduction to Welding*. Stillwater, Oklahoma: Mid-America Vocational Curriculum Consortium, Inc. 1984.

B. Hendrix, Laborn J. "Bud." *Fundamentals of Carpentry*. Stillwater, Oklahoma: Oklahoma State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center, and The Associated General Contractors of America, 1985.

C. Hendrix, Laborn J. "Bud." *Commercial Carpentry*. Stillwater, Oklahoma: Oklahoma State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center, and The Associated General Contractors of America, 1986.

WELDING TOOLS
UNIT II

INFORMATION SHEET

I. Terms and definitions associated with welding tools

A. **Arc** — Flow of current across a narrow gap, usually from tip of electrode to base metal

B. **Arc welding** — Joining of two or more pieces of metal by fusion process

(NOTE: Arc welding is sometimes referred to as "SMAW" or "stick welding.")

C. **Fusion** — Process of liquefying by melting

D. **Keyway** — Groove cut into a shaft to accept a key

E. **Lead** — Cable leading from ground clamp and electrode holder to the welding machine

F. **Slag** — Non-metallic porous material trapped in the weld metal or between the weld metal and base metal

G. **Tacked** — Process of temporarily welding parts in alignment until final welds are made

H. **Tolerance** — Acceptable variation from a standard size

II. Abbreviations associated with welding

A. **AC** — Alternating current; electric current that reverses its direction at regular intervals

B. **AWS** — American Welding Society

C. **DC** — Direct current; electric current flowing in one direction only and mostly constant in value

D. **OSHA** — Occupational Safety and Health Act; federal legislation designed to ensure safe and sanitary working conditions for employees

E. **psi** — Pounds per square inch

F. **GMAW** — Gas metal arc welding

G. **SMAW** — Shielded metal arc welding

INFORMATION SHEET

III. Types of arc welding machines

A. AC or alternating current

(NOTE: Alternating current alternates direction 120 times per second.)

B. DC or direct current

(NOTE: Direct current flows in one direction.)

C. Electric motor generator

(NOTE: This generator produces only DC current.)

D. Engine generator

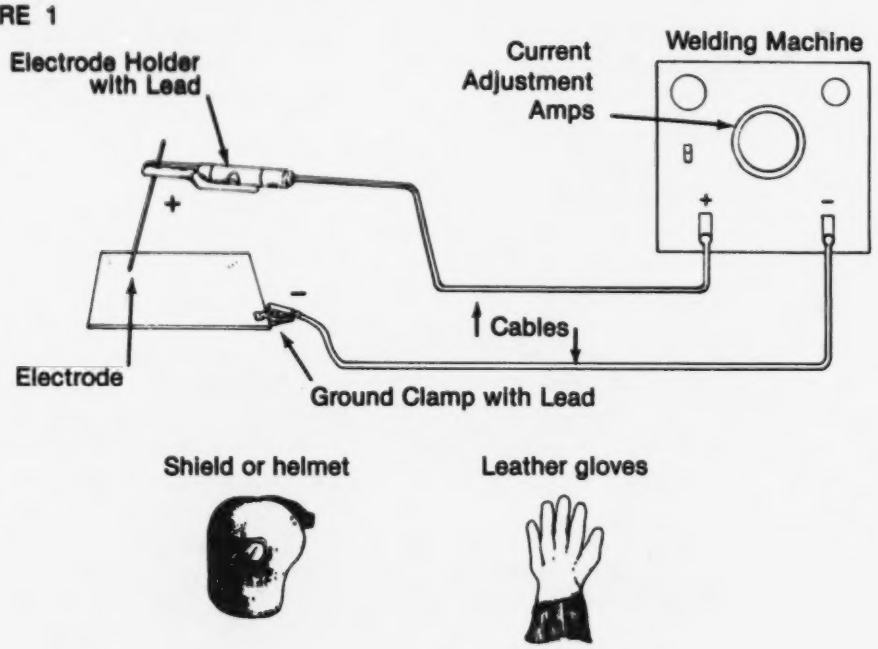
(NOTE: This is an alternating type generator and will produce either AC or DC current.)

E. AC/DC transformer-rectifier

(NOTE: This welding machine, which is supplied by an AC power source, can be switched to produce either AC or DC welding current.)

IV. Common equipment used in arc welding (Figure 1)

FIGURE 1

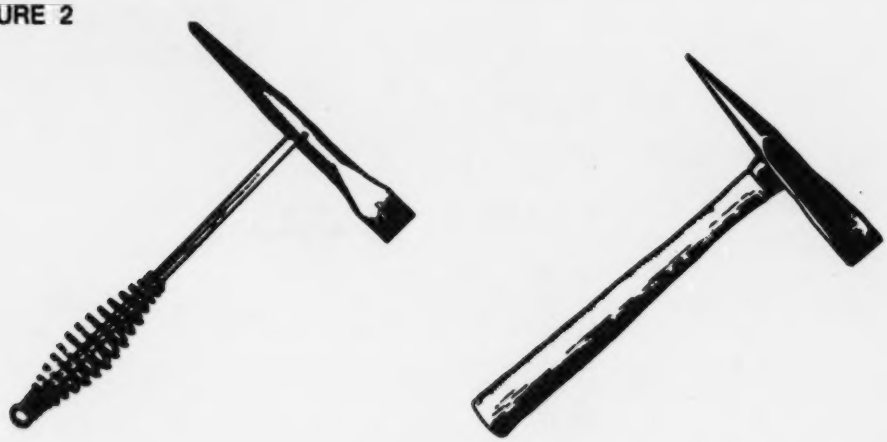


INFORMATION SHEET

V. Types of hammers and their characteristics and uses (Figures 2-4)

A. Chipping hammer — Used to remove slag and residue left on metals after welding or cutting

FIGURE 2

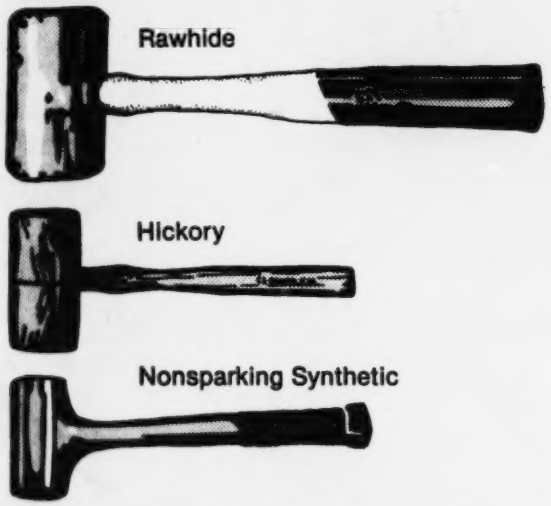


B. Fitter's or engineer's hammer — Heavy hammer with two driving heads used to drive wedges under and between materials; comes in weights of 40, 48 and 64 ounces

FIGURE 3

C. Mallets — Used where a metal hammer would damage material; made of hickory, rawhide, lead, nylon, rubber, or composition materials

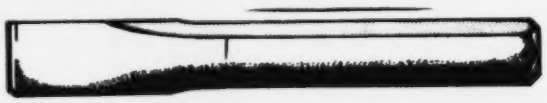
FIGURE 4



VI. Types of chisels and punches and their uses (Figures 5-10)

A. Cold chisel — Used for cutting metal, rivets, nuts, and bolts

FIGURE 5



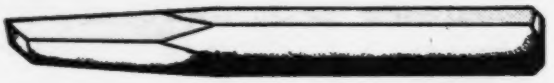
B. Cape chisel — Used for cutting keyways in metal

FIGURE 6

INFORMATION SHEET

C. Diamond-point chisel — Used for cutting V-grooves and cleaning out inside corners

FIGURE 7

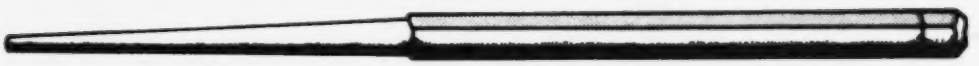


D. Round-nose chisel — Used for cutting U-shaped grooves in metal

FIGURE 8

E. Drift punch — Used for driving out straight or tapered pins

FIGURE 9



F. Center punch — Used to make puncture marks, to locate centers of holes, or to establish work points or center lines on materials

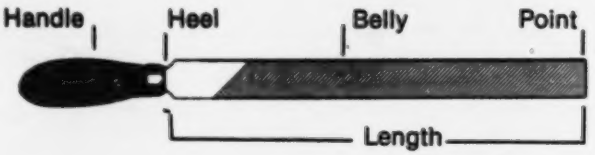
FIGURE 10

INFORMATION SHEET

VII. Files, their uses, basic shapes, and cuts (Figures 11-15)

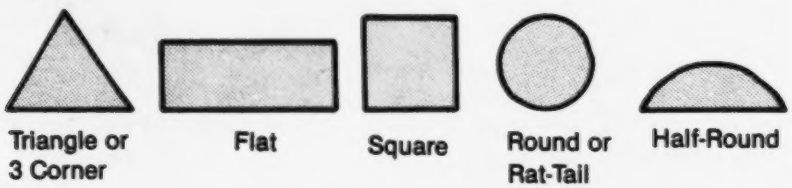
A. Files — Used manually to remove metal stock

FIGURE 11



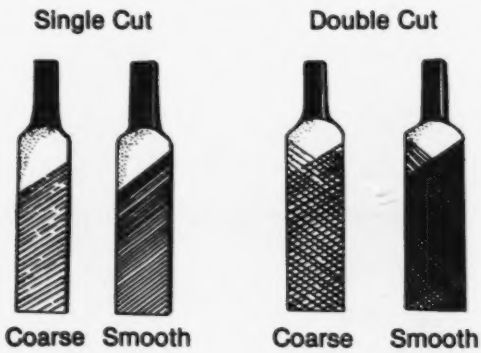
B. Basic shapes of files — Triangular, flat, square, round or rat-tail, and half-round to provide a shape to match the job needed

FIGURE 12



C. Basic file cuts — From single-cut coarse to double-cut smooth to provide textures that produce specific finishes

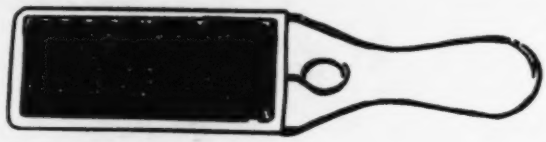
FIGURE 13



INFORMATION SHEET

D. Card file — Used to clean file

FIGURE 14



E. File handle — Used to cover the tang of a file and to protect against injury; a file should not be used without a handle

FIGURE 15

VIII. Wire brushes and their types and uses (Figure 16)

A. Uses — For cleaning a weld area before or after welding; also used to clean rust, corrosion and paint from metal

B. Types — Steel wire bristles or stainless steel bristles with shoe handles or bent handles

FIGURE 16

INFORMATION SHEET

IX. Holding and anchoring tools and their characteristics and uses (Figures 17-19)

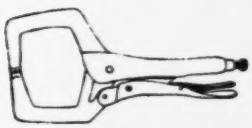
A. Vise-grip clamps — Pliers-type devices used to hold materials until they can be tacked in place; adjustable to almost any metal gauge and handy to work with because they are easily attached and removed

FIGURE 17

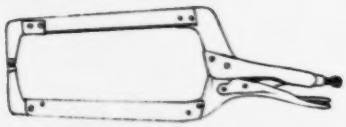
Curved Jaw

Straight Jaw

Sheet Metal Tool



C-Clamp



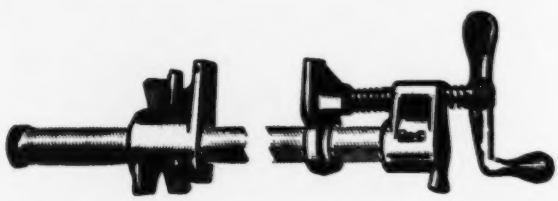
Long-Reach C-Clamp

Welding Clamp

Chain Clamp

B. Bar clamps — Adjustable vise-like devices used to hold materials together until they can be joined by other means; will hold longer and wider materials than a vise

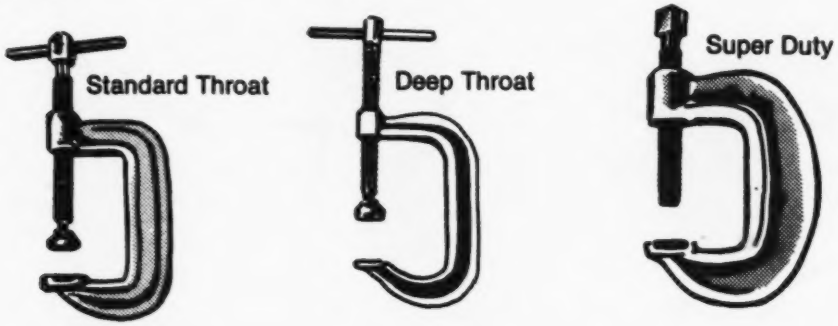
FIGURE 18



INFORMATION SHEET

C. C-clamps — Used to hold two or more pieces of material together until they can be tacked or joined together by other means

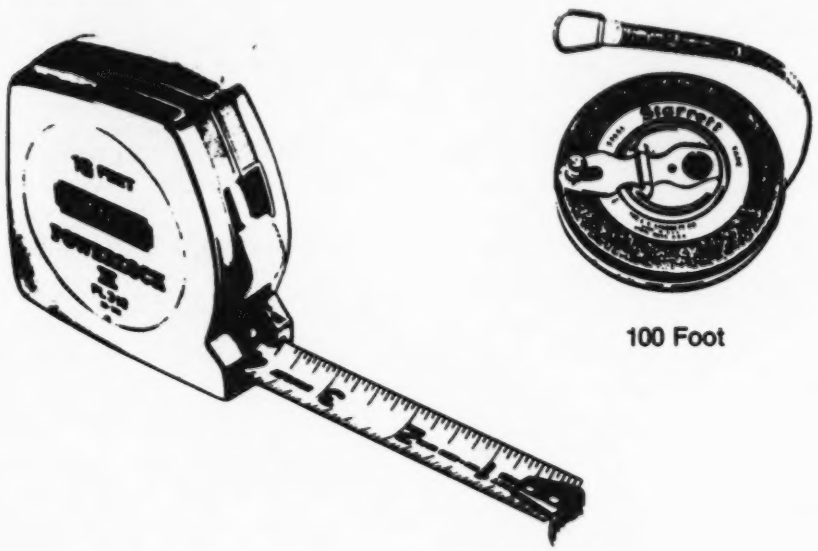
FIGURE 19



X. Measuring instruments and their characteristics and uses (Figures 20-22)

A. Steel tape — Used to measure gauges, set lines, holes, workpoints, and layout work, and for squaring

FIGURE 20



100 Foot

INFORMATION SHEET

B. Wing divider — Used to construct small circles and arcs and to transfer measurements

FIGURE 21

C. Temperature stick — Used during the heating process to determine temperature of metal; mark dissipates when metal or part reaches the proper temperature

(NOTE: Temperature sticks come in a variety of colors and a wide variety of heat ranges.)

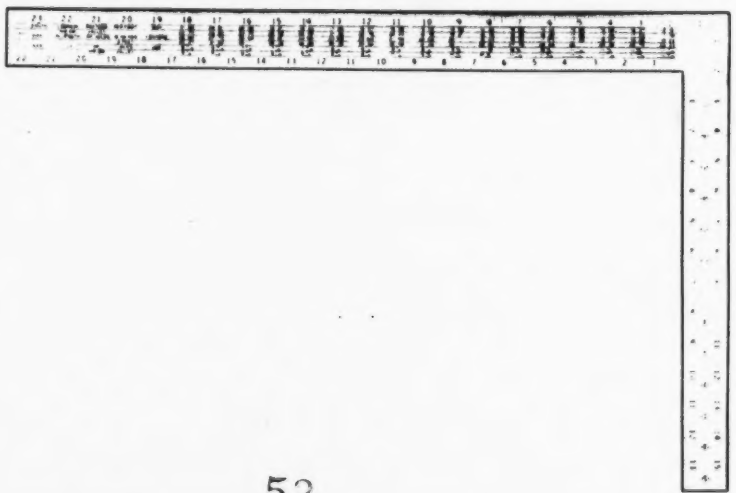
FIGURE 22

Temp-Stick

XI. Types of squares and their characteristics and uses (Figures 23-25)

A. Framing square — Used primarily by welders to check trueness of flanges and angles; used for setting and checking bevel squares and for layout work

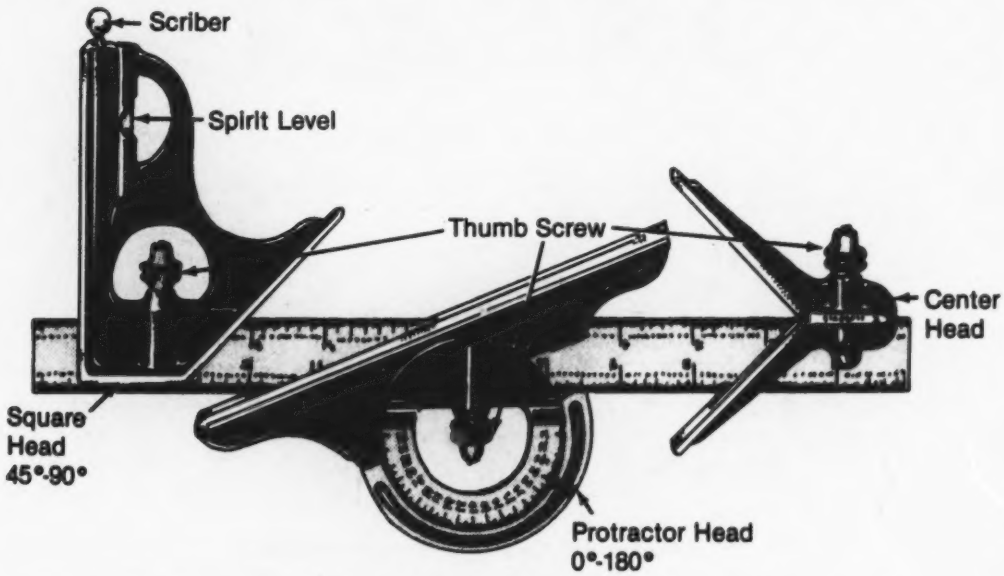
FIGURE 23



INFORMATION SHEET

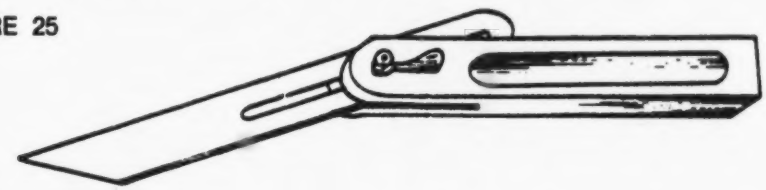
B. Combination square — Used to square detail material; square head is used for 45° to 90° angles, protractor head is used to read angles from 0° to 180°, and center head is used to find the center of round materials

FIGURE 24



C. Bevel square — Used to lay out bevel lines or check materials cut on a bevel; can be adjusted to all angles

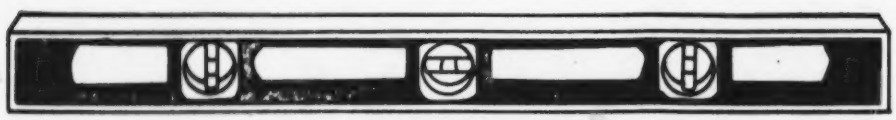
FIGURE 25



XII. Types of hand levels and their characteristics and uses. (Figures 26-27)

A. Spirit level — Used to check level of surfaces, plumb and align related members vertically or at a 45° angle

FIGURE 26



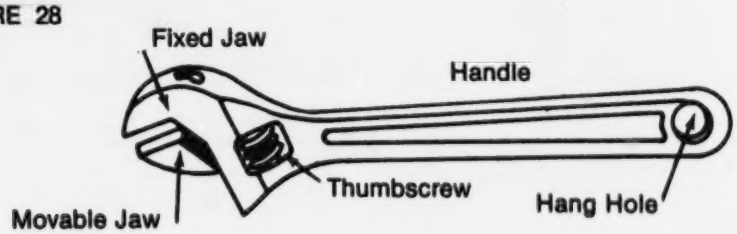
B. Torpedo level — Used to check level, grade, or plumb of short members such as stair risers and treads

FIGURE 27

XIII. Types of wrenches and their uses (Figures 28-30)

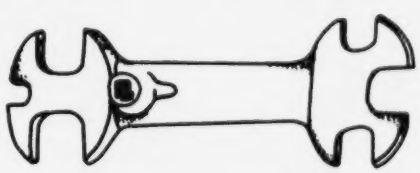
A. Adjustable wrench — Used to tighten or loosen different sizes of nuts and bolts and other fittings

FIGURE 28



B. Cylinder wrench — Used specifically for tightening or loosening cylinder connections on oxyacetylene equipment because adjustable wrenches can easily damage the brass fittings used on oxyacetylene equipment

FIGURE 29



C. Torch wrench — Used specifically for tightening or loosening torch connections when the use of adjustable wrenches or pliers might damage brass fittings

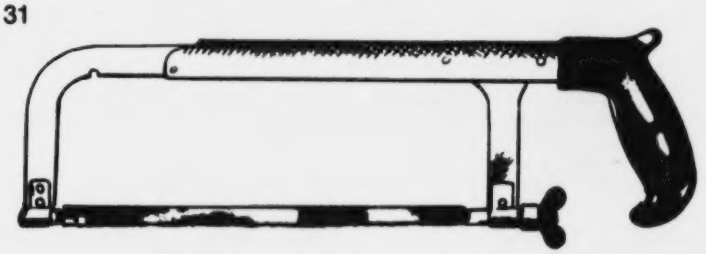
FIGURE 30

INFORMATION SHEET

XIV. Types of cutting and shaping tools and their uses (Figures 31-34)

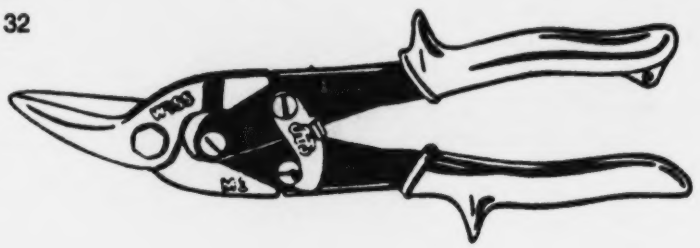
A. Hacksaw — Used to manually cut or separate metal

FIGURE 31



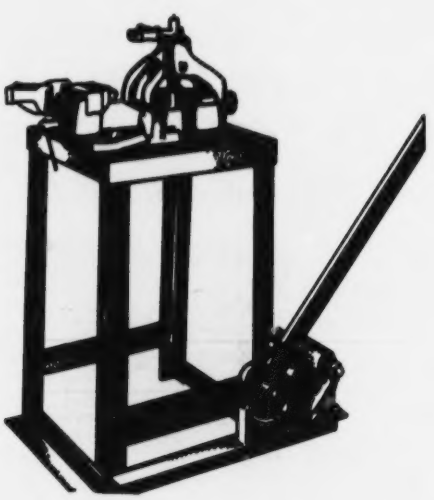
B. Straight-cut snips — Used to cut straight lines or curves on light-gauge metal; also available in left or right cuts

FIGURE 32



C. Angle iron cutter, notcher, and bender — Used to cut, notch, and bend angle iron

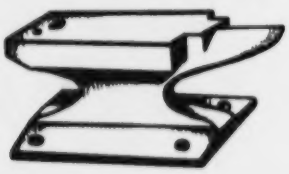
FIGURE 33



INFORMATION SHEET

D. Anvil — Iron or steel block with both flat and curved surfaces for shaping metal that are hammered or peened against it; it sometimes has a tapered round end for curving metal strapping and other materials

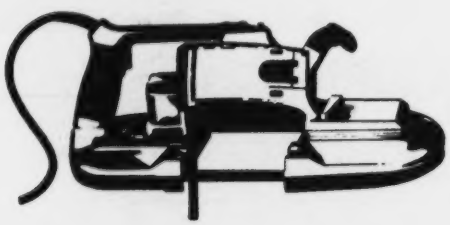
FIGURE 34



XV. Portable power tools used by welders (Figures 35-36)

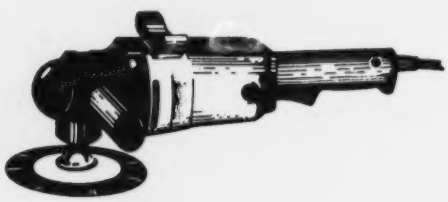
A. Portable band saw

FIGURE 35



B. Portable hand grinder

FIGURE 36



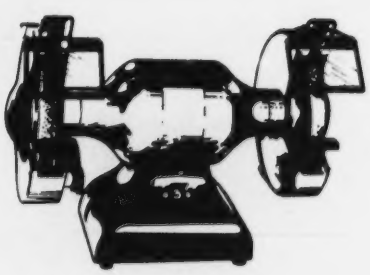
XVI. Stationary power tools used by welders (Figures 37-41)

A. Grinders

FIGURE 37

Pedestal

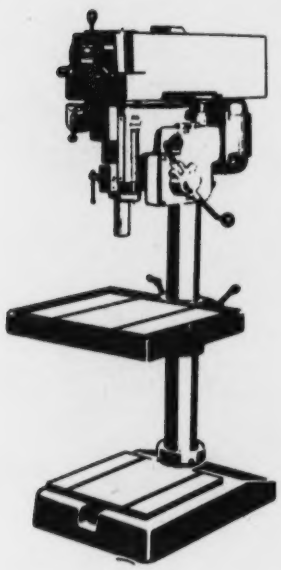
Bench



INFORMATION SHEET

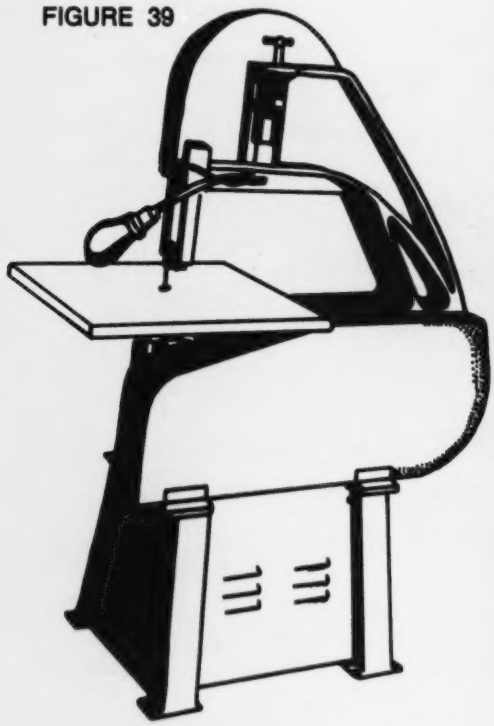
B. Drill press

FIGURE 38



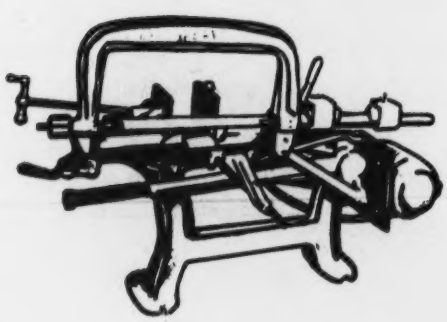
C. Vertical band saw

FIGURE 39



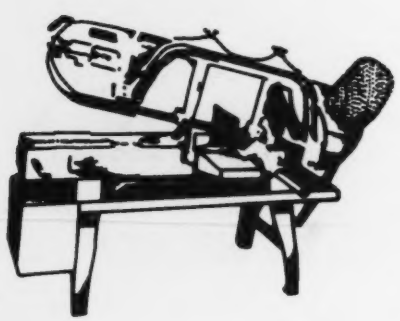
D. Power hacksaw

FIGURE 40



E. Horizontal band saw (metal cutting)

FIGURE 41



INFORMATION SHEET

XVII. Guidelines for safe use and care of hand tools

A. Use the correct tool for the job

B. Keep appropriate tools sharp

C. Keep tools clean

D. Inspect tools frequently to make sure they are in good condition

E. Repair broken or damaged tools promptly

F. Dispose of broken or damaged tools that cannot be repaired

G. Secure small parts or objects before working on them

H. Store tools properly when not in use

EXAMPLES: Do not carry tools in your pockets; do not place tools on workbench where they can roll off; protect cutting edges; lightly oil tools before storing; store tools in a dry place

I. Stay alert when using tools

EXAMPLES: Keep fingers away from cutting edge; work away from your body when using cutting tools; pull wrenches toward yourself to prevent smashing your hand if wrench should slip.

J. Wear eye protection always

XVIII. General safety rules pertaining to power tools and equipment

(NOTE: Power tools may be operated by electricity [AC or DC current], air, combustion engines, or explosive powder.)

A. Do not attempt to operate any power tool before being checked out by instructor on that particular tool

B. Always wear eye protection and hard hat when operating a power tool

C. Wear appropriate clothing for job being done

(NOTE: Always wear tight-fitting clothing that cannot be caught in the moving tool. Roll up long sleeves, tuck in shirttails, and tie back long hair.)

D. Do not distract others or let anyone distract you while operating a power tool

E. Do not leave power tool running unattended

F. Assume a safe and comfortable position before using a power tool

G. Be sure that power tools are properly grounded before using

H. Be sure power tool is disconnected before performing maintenance or changing accessories

INFORMATION SHEET

I. Do not use dull or broken tools or accessories

J. Use a power tool only for its intended use

K. Keep fingers, feet, and hair away from blades and other moving parts of a power tool

L. Do not use a power tool with guards or safety devices removed

M. Do not operate a power tool if your hands or feet are wet

N. Keep work area clean at all times

O. Be familiar with the correct operation and adjustments of a power tool before attempting to use it

P. Keep a firm grip on the power tool at all times

Q. Use electric extension cords of sufficient size to service the particular power tool you are using

R. Avoid walking into restricted safety zones marked off around power equipment

S. Know emergency shut-down procedures for all power equipment

XIX. Guidelines for proper care of power tools and equipment

CAUTION

Always disconnect the power supply when performing maintenance or changing accessories on power tools and equipment.

A. Inspect tools and accessories regularly

B. Keep tools clean and in good working order

C. Follow manufacturer's maintenance procedures

D. Protect cutting edges

E. Keep all tool accessories such as blades and bits sharp

F. Use appropriate blade for the arbor size

G. Report any unusual noises, sounds, or vibrations to the instructor or supervisor

H. Keep tools in their proper place when not in use

WELDING TOOLS
UNIT II

TEST

NAME _____ SCORE _____

1. Match to their correct definitions terms associated with welding tools. Write the correct numbers in the blanks.

_____a.	Flow of current across a narrow gap, usually from tip of electrode to base metal	1. Arc welding
_____b.	Joining of two or more pieces of metal by fusion process	2. Keyway
_____c.	Cable leading from ground clamp and electrode holder to the welding machine	3. Lead
_____d.	Non-metallic porous material trapped in the weld metal or between the weld metal and base metal	4. Arc
_____e.	Groove cut into a shaft to accept a key	5. Tolerance
_____f.	Process of temporarily welding parts in alignment until final welds are made	6. Slag
_____g.	Process of liquefying by melting	7. Tacked
_____h.	Acceptable variation from a standard size	8. Fusion

2. State the meanings of abbreviations associated with welding. Write the correct answers in the blanks.

a. DC — _____

b. SMAW — _____

c. AC — _____

d. psi — _____

e. AWS — _____

f. OSHA — _____

g. GMAW — _____

TEST

3. Name three types of arc welding machines.

   a. _____

   b. _____

   c. _____

4. Select from the following list common equipment used in arc welding. Write an "X" in the correct blanks.

   _____a. Shield or helmet
   _____b. Electrode
   _____c. Welding machine
   _____d. Cutting torch
   _____e. Cables
   _____f. Electrode holder with lead
   _____g. Oxyacetylene tank
   _____h. Leather gloves
   _____i. Ground clamp with lead

5. Match the following hammers with their characteristics and uses. Write the correct numbers in the blanks.

   _____a. Used to remove slag and residue left on metals after welding or cutting
   _____b. Heavy hammer with two driving heads used to drive wedges under and between materials; comes in weights of 40, 48 and 64 ounces
   _____c. Used where a metal hammer would damage material; made of hickory, rawhide, lead, nylon, rubber, or composition materials

   1. Fitter's or engineer's
   2. Chipping
   3. Mallet
   4. Ball peen

6. Match the folowing chisels and punches with their uses. Write the correct numbers in the blanks.

   _____a. Used for cutting metal, rivets, nuts, and bolts
   _____b. Used for cutting keyways in metal
   _____c. Used for cutting V-grooves and cleaning out inside corners
   _____d. Used for cutting U-shaped grooves in metal
   _____e. Used for driving out straight or tapered pins
   _____f. Used to make puncture marks, to locate centers of holes, or to establish work points or center lines on materials

   1. Round-nose chisel
   2. Center punch
   3. Cold chisel
   4. Diamond-point chisel
   5. Drift punch
   6. Cape chisel

TEST

7. Select from a list statements concerning files and their uses, basic shapes and cuts. Place an "X" in the correct blanks.

_____a. Basic file cuts — From single-cut coarse to double-cut smooth to provide textures that produce specific finishes

_____b. Card file — Used to sharpen files

_____c. File handle — Used to cover the tang of a file and to protect against injury

_____d. Basic shapes of files — Triangular, flat, square, round or rat-tail, and half-round to provide a shape to match the job needed

_____e. File — Used manually to remove metal stock

8. Select from a list statements concerning wire brushes and their shapes and uses. Write an "X" in the correct blanks.

_____a. Used to clean rust, corrosion and paint from metal

_____b. Steel wire bristles or stainless steel bristles with rat-tail handles

_____c. Used for cleaning a weld area before or after welding

9. Match the following holding and anchoring tools with their characteristics and uses. Write the correct numbers in the blanks. There may be more than one number for each blank.

_____a. Pliers-type devices used to hold materials until they can be tacked in place; adjustable to almost any metal gauge and handy to work with because they are easily attached and removed

_____b. Adjustable vise-like devices used to hold materials together until they can be joined by other means; will hold longer and wider materials than a vise

_____c. Used to hold two or more pieces of material together until they can be tacked or joined together by some other means

1. Chain clamp
2. Straight jaw vise grip
3. Deep throat C-clamp
4. C-clamp vise grip
5. Sheet metal tool vise grip
6. Super duty C-clamp
7. Bar clamp
8. Long-reach C-clamp vise grip
9. Curved jaw vise grip
10. Standard throat C-clamp
11. Welding clamp vise grip

TEST

10. Match the following measuring instruments with their characteristics and uses. Write the correct numbers in the blanks.

_____a. Used to measure gauges, set lines, holes, workpoints and layout work, and for squaring

_____b. Used to construct small circles and arcs and to transfer measurements

_____c. Used during the heating process to determine the temperature of metal; mark dissipates when metal or part reaches the proper temperature

1. Wing divider
2. Temperature stick
3. Steel tape

11. Match the following squares with their characteristics and uses. Write the correct numbers in the blanks.

_____a. Used primarily by welders to check trueness of flanges and angles; used for setting and checking bevel squares and for layout work

_____b. Used to square detailed material; square head is used for 45° and 90° angles, protractor head is used to read angles from 0° to 180°, and center head is used to find the center of round materials

_____c. Used to lay out bevel lines or check materials cut on a bevel; can be adjusted to all angles

1. Bevel square
2. Combination square
3. Framing square

12. Match the following types of hand levels with their characteristics and uses. Write the correct numbers in the blanks.

_____a. Device used to check level of surfaces, plumb and align related members vertically or at a 45° angle

_____b. Used to check level, grade or plumb of short members such as stair risers and treads

1. Spirit level
2. Torpedo level
3. Framing level

13. Match the following types of wrenches to their uses. Write the correct numbers in the blanks.

_____a. Used specifically for tightening or loosening cylinder connections on oxyacetylene equipment

_____b. Used specifically for tightening or loosening torch connections when the use of other wrenches or pliers might damage brass fittings

_____c. Used to tighten or loosen different sizes of nuts and bolts and other fittings

1. Cylinder wrench
2. Adjustable wrench
3. Crescent wrench
4. Torch wrench

TEST

14. Match the following cutting and shaping tools with their uses. Write the correct numbers in the blanks.

_____a. Used to manually cut or separate metal

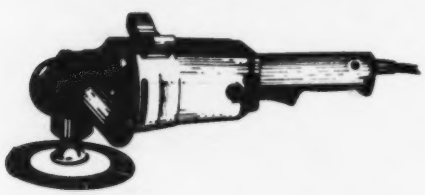
_____b. Used to cut straight lines or curves on light-gauge metal; also available in left or right cuts

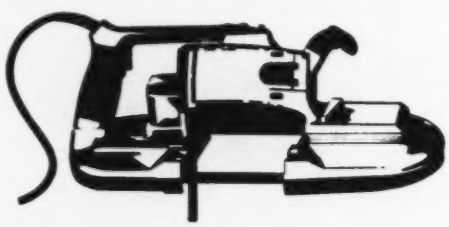
_____c. Used to cut, notch, and bend angle iron

_____d. Iron or steel block with both flat and curved surfaces for shaping metals that are hammered or peened against it; it sometimes has a tapered round end for curving metal strapping and other materials

1. Anvil
2. Straight-cut snips
3. Hacksaw
4. Angle iron cutter, notcher, and bender

15. Identify the following portable power tools used by welders. Write the correct names in the blanks.

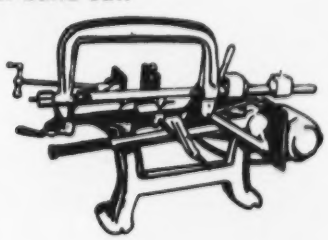




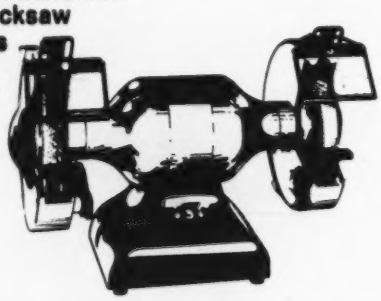
a. _____ b. _____

16. Identify the following stationary power tools used by welders. Write the correct names in the blanks.

Bench grinder
Pedestal grinder
Vertical band saw

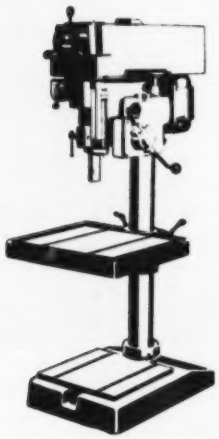


Horizontal band saw
Power hacksaw
Drill press



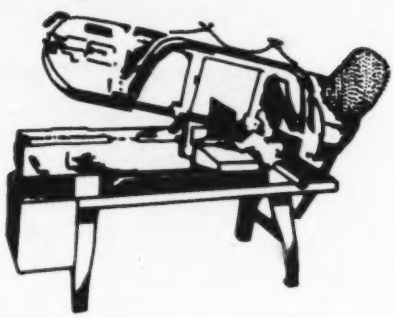
a. _____ b. _____

TEST

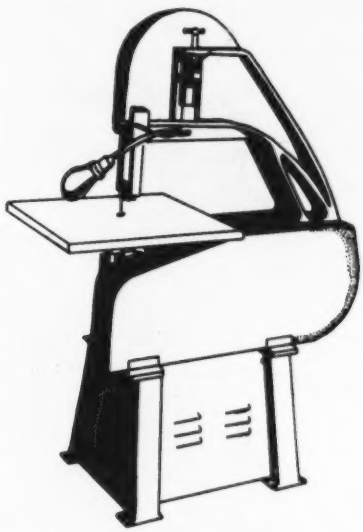


c. _____

d. _____



e. _____



f. _____

TEST

17. State five guidelines for safe use and care of hand tools.

a. _____

b. _____

c. _____

d. _____

e. _____

18. State ten general safety rules pertaining to power tools.

a. _____

_____

b. _____

_____

c. _____

_____

d. _____

_____

e. _____

_____

f. _____

_____

g. _____

_____

h. _____

_____

i. _____

_____

j. _____

_____

TEST

19. State five guidelines for proper care of power tools and equipment.

a. _____

b. _____

c. _____

d. _____

e. _____

WELDING TOOLS
UNIT II

ANSWERS TO TEST

1. a. 4 c. 3 e. 2 g. 8
   b. 1 d. 6 f. 7 h. 5

2. a. DC — Direct current; electric current flowing in one direction only and mostly constant in value
   b. SMAW — Shielded metal arc welding
   c. AC — Alternating current; electric current that reverses its direction at regular intervals
   d. psi — pounds per square inch
   e. AWS — American Welding Society
   f. OSHA — Occupational Safety and Health Act; federal legislation designed to ensure safe and sanitary working conditions for employees
   g. GMAW — Gas metal arc welding

3. Answer should include any three of the following

   a. AC or alternating current
   b. DC or direct current
   c. Electric motor generator
   d. Engine generator
   e. AC/DC transformer-rectifier

4. a, b, c, e, f, h, i

5. a. 2 b. 1 c. 3

6. a. 3 c. 4 e. 5
   b. 6 d. 1 f. 2

7. a, c, d, e

8. a, c

9. a. 1, 2, 4, 5, 8, 9, 11 b. 7 c. 3, 6, 10

10. a. 3 b. 1 c. 2

ANSWERS TO TEST

11. a. 3 b. 2 c. 1

12. a. 1 b. 2

13. a. 1 b. 4 c. 2

14. a. 3 c. 4
    b. 2 d. 1

15. a. Portable hand grinder b. Portable band saw

16. a. Power hacksaw
    b. Bench grinder
    c. Drill press
    d. Pedestal grinder
    e. Horizontal band saw
    f. Vertical band saw

17. Answer should include any five of the following

    a. Use the correct tool for the job
    b. Keep appropriate tools sharp
    c. Keep tools clean
    d. Inspect tools frequently to make sure they are in good condition
    e. Repair broken or damaged tools promptly
    f. Dispose of broken or damaged tools that cannot be repaired
    g. Secure small parts or objects before working on them
    h. Store tools properly when not in use
    i. Stay alert when using tools
    j. Wear eye protection always

18. Answer should include any ten of the following

    a. Do not attempt to operate any power tool before being checked out by instructor on that particular tool
    b. Always wear eye protection and hard hat when operating a power tool
    c. Wear appropriate clothing for job being done
    d. Do not distract others or let anyone distract you while operating a power tool
    e. Do not leave power tool running unattended
    f. Assume a safe and comfortable position before using a power tool
    g. Be sure power tools are properly grounded before using
    h. Be sure power tool is disconnected before performing maintenance or changing accessories
    i. Do not use dull or broken tools or accessories
    j. Use a power tool only for its intended use

ANSWERS TO TEST

k. Keep fingers, feet, and hair away from blades and other moving parts of a power tool
l. Do not use a power tool with guards or safety devices removed
m. Do not operate a power tool if your hands or feet are wet
n. Keep work area clean at all times
o. Be familiar with the correct operation and adjustment of a power tool before attempting to use it
p. Keep a firm grip on the power tool at all times
q. Use electric extension cords of sufficient size to service the particular power tool you are using
r. Avoid walking into restricted safety zones marked off around power equipment
s. Know emergency shut-down procedures for all power equipment

19. Answer should include any five of the following

a. Inspect tools and accessories regularly
b. Keep tools clean and in good working order
c. Follow manufacturer's maintenance procedures
d. Protect cutting edges
e. Keep all tool accessories such as blades and bits sharp
f. Use appropriate blade for the arbor size
g. Report any unusual noises, sounds, or vibrations to the instructor or supervisor
h. Keep tools in their proper place when not in use

WELDING LAYOUT AND BASIC SKILLS
UNIT III

UNIT OBJECTIVE

After completing this unit, the student should be able to identify basic welding symbols and perform various welding jobs. The student will show this ability by completing job sheets and unit test with a minimum score of 80 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match terms associated with welding layout and basic skills to their correct definitions.
2. State safety precautions to observe when welding.
3. Select from a list common tools and equipment used in arc welding.
4. Distinguish between reverse and straight polarity.
5. Select from a list factors that determine correct polarity to use.
6. Select from a list purposes of electrode flux.
7. List factors to consider when selecting electrodes.
8. Describe effects of raising and lowering welding machine amperes.
9. Name methods of striking an arc.
10. Select from a list characteristics of proper arc length.
11. Identify parts of the welding process.
12. Match types of welds to their correct descriptions.
13. Label types of weld joints.
14. Identify parts of groove and fillet welds.
15. List positions used in arc welding.
16. List reasons for poor welds.
17. List types of electrode motions (rod manipulations).
18. State characteristics of a good weld.

OBJECTIVE SHEET

19. Match elements of welding symbols to their correct descriptions.
20. Draw symbols showing location of weld.
21. Identify basic weld symbols.
22. Distinguish between correct and incorrect drawings of symbols with one vertical side.
23. Identify supplementary symbols.
24. Interpret finish symbols used with contour symbols.
25. Demonstrate ability to
    a. Start, stop, and restart a bead.
    b. Construct a pad weld.
    c. Construct a butt weld.

WELDING LAYOUT AND BASIC SKILLS
UNIT III

SUGGESTED ACTIVITIES

I. Unit contents

A. Objective sheet

B. Suggested activities

C. Transparency masters

1. TM #1 — Welding Circuit
2. TM #2 — Elements of Welding Symbols
3. TM #3 — Standard Location of Welding Symbol Elements
4. TM #4 — Application of Fillet Welding Symbol
5. TM #5 — Application of Plug Welding Symbol
6. TM #6 — Application of Slot Welding Symbol
7. TM #7 — Application of Spot Welding Symbol
8. TM #8 — Application of Seam Welding Symbol
9. TM #9 — Application of Square-Groove Welding Symbol
10. TM #10 — Application of V-Groove Welding Symbol
11. TM #11 — Application of Bevel-Groove Welding Symbol
12. TM #12 — Application of U-Groove Welding Symbol
13. TM #13 — Application of J-Groove Welding Symbol
14. TM #14 — Application of Flared V-Groove Welding Symbol
15. TM #15 — Application of Flared Bevel-Groove Welding Symbol
16. TM #16 — Application of Edge-Flange Welding Symbol
17. TM #17 — Application of Corner-Flange Welding Symbol

D. Information sheet

E. Job sheets

SUGGESTED ACTIVITIES

1. Job Sheet #1 — Start, Stop, and Restart a Bead
2. Job Sheet #2 — Construct a Pad Weld
3. Job Sheet #3 — Construct a Butt Weld

F. Test

G. Answers to test

II. Instructor's guide

A. Review unit and plan presentation.

B. Obtain materials to supplement unit.

1. Electrode selection wall chart and electrode guide books

   (NOTE: Obtain from your local welding supplier.)

2. Film — *Arc Welding*, 30 minutes, color, Association Films, 1971. Available from Association Films, 600 Grand Avenue, Richfield, New Jersey, 07657.

   (NOTE: This film explains major arc welding processes, required equipment, and progress made in the field. It is available to Oklahoma teachers on a free-loan basis from the Oklahoma State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center Film Library, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364. Out-of-state teachers must order from the address listed above.)

3. Clean 1/4-inch, 3/8-inch, and 3/16-inch plates and coupons for the students to weld on

   (NOTE: Check other catalogs and resources, and order materials needed.)

4. Competency profile

   (NOTE: A master of the competency profile for this book is provided at the front of the instructor edition. You may duplicate the profile and distribute it to students as needed.)

C. Make a sample pad and butt welds like those to be made in the job sheets, as well as samples of the different types of welds and joints illustrated on the transparencies.

D. Check all welding equipment for proper condition and quantity: helmets, electrodes, helmet lenses, safety glasses, and gloves.

SUGGESTED ACTIVITIES

E. Have students begin bringing to class proper protective clothing; provide a storage place for the clothes.

F. Introduce unit by emphasizing the benefits of knowing how to arc weld.

- Stress the increased job opportunities that exist for workers who are also good welders.
- Emphasize to students that they can save money by making their own repairs and construction projects for which they would otherwise have to hire a welder.

G. Provide students with objective sheet.

H. Discuss unit and specific objectives.

- Emphasize the important of being familiar with the terms and definitions in order to understand and be able to communicate the technical terminology associated with arc welding.
- Point out how the information in the unit will build through the unit to prepare the student to actually perform the job sheets at the end of the unit.

I. Provide students with information and job sheets.

J. Discuss information sheet.

1. Use Information Sheet, Section I, to discuss terms and definitions associated with arc welding.
   - Show actual equipment to illustrate some of the terms and definitions.
   - Use a small ball-peen hammer and metal plate to crumble flux from an electrode when discussing electrodes and flux.
2. Use Information Sheet, Section II, to discuss safety precautions in arc welding.
   - Cite instances with which you are familiar that may have resulted in an accident or tragedy due to someone's lack of observing and practicing proper safety precautions.
   - Allow students to share instances that they may know of that resulted from not observing proper safety precautions.
   - Discuss each safety precaution as it relates specifically to personal safety and the safety of others in the immediate work area.
   - Discuss the importance of using the proper lens as shown in the table on the following page.

SUGGESTED ACTIVITIES

EXAMPLE:

LENS—SHADE SELECTOR	
Shade Number	Type of Operation
2	Soldering
3 or 4	Torch brazing
3 or 4 3 or 5 5 or 6	Oxygen cutting 0 to 1 inch 1 to 6 inches 6 inches and over
4 or 5 5 or 6 6 or 8	Gas welding 0 to 1/3 inch 1/8 to 1/2 inch 1/2 inch and over
9 to 14	Shielded metal-arc welding 1/16-, 3/4-, 1/8-, 5/32-inch electrodes
9 to 14	Gas-metal arc welding
9 to 14	Gas-tungsten arc welding nonferrous gas-metal arc welding 1/16-, 3/32-, 1/8-, 5/32-inch electrodes
9 to 14	Gas-tungsten arc welding (ferrous), gas-metal arc welding (ferrous) 1/16-, 3/32-, 1/8-, 5/32-inch electrodes

3. Use Information Sheet, Section III, to discuss common arc welding equipment.

   - Take students to the shop to show them the components that make up the arc welding equipment.
   - Explain to the students what to look for when checking the equipment to make sure that it is in good condition.
   - Demonstrate to the students how to make helmet adjustments and lens changes.
   - Show students the result of handling hot metal with leather gloves.
   - Show the film, *Arc Welding*. After showing the film, allow for student/teacher discussion of the film.

SUGGESTED ACTIVITIES

4. Use Information Sheet, Sections IV and V, and Transparency #1 to discuss polarity and factors in determining correct polarity; demonstrate how to use an electrode guide book.

5. Use Information Sheet, Sections VI and VII, and an electrode handbook to discuss selection of electrodes; relate electrodes commonly used in construction to their uses.

6. Use Information Sheet, Section VIII, to discuss the effects of raising and lowering current settings on arc welding machines.

   - Use thin plate to demonstrate how raising the current can produce enough heat to burn a hole completely through the metal. Point out that a much lower current setting will not burn through the metal.

   - Explain that on the electrodes selection wall chart, different current settings are suggested for different thicknesses of metal and different electrode sizes.

7. Use Information Sheet, Section IX, to discuss methods of striking an arc.

   - Demonstrate the procedures of striking an arc in the classroom, using a metal plate and an electrode, or take students to the shop and equip them with helmets so that they may watch an on-the-job demonstration.

8. Use Information Sheet, Section X, to discuss characteristics of proper arc length.

   - Demonstrate arc length in the shop with small groups of students gathered around a welding table where they can see the length of arc being maintained.

9. Use Information Sheet, Section XI, to discuss parts of the welding process.

   - Emphasize the importance of proper arc length.

   - Demonstrate the actual welding process in the shop by running a bead.

   - Invite a local welder to demonstrate the welding process to the students. Have the welder discuss the important aspects of the process.

10. Use Information Sheet, Sections XII through XIV, to discuss types of welds and joints.

    - Show prepared samples of actual weld joints.

    - Point out that the bead weld is used to make an edge joint.

    - Point out that a groove weld is used to make a butt joint.

SUGGESTED ACTIVITIES

- Point out that the fillet weld is used to make T, corner, and lap joints.
- Demonstrate Job Sheets #1 through #3.

11. Use Information Sheet, Section XV, to discuss weld positions.
    - Simulate the positions in the classroom with a hand-held piece of metal and hand-held electrode.
    - Demonstrate the positions by performing welding activities in the shop.
    - Invite a local welder to demonstrate the various welding positions.
    - Relate the positions to construction tasks.
12. Use Information Sheet, Section XVI, to discuss reasons for poor welds.
    - Point out to the students that much of the information discussed thus far relates and applies to making either high-quality or poor welds.
    - Show and discuss prepared examples of poor welds as related to each of the reasons for poor welds listed.
    - Explain how you will use the characteristics of a good weld to evaluate the students' projects.
    - Allow students to practice procedures.
13. Use remaining sections of Information Sheet and remaining transparencies to discuss welding symbols.
    - Show the students examples of various symbols on commercial blueprints and details.
    - Have an architect or architectural engineer explain the use of symbols.
    - Visit a job site to see symbols translated into welds.
    - Make flashcards of symbols and have students explain what they mean.
    - Provide students with weld symbols and specifications and have them make the welds described.

K. Review unit.

L. Give test.

M. Critique test and discuss in class.

SUGGESTED ACTIVITIES

N. Reteach and retest as necessary.

O. Complete appropriate sections of competency profile.

III. Unit references

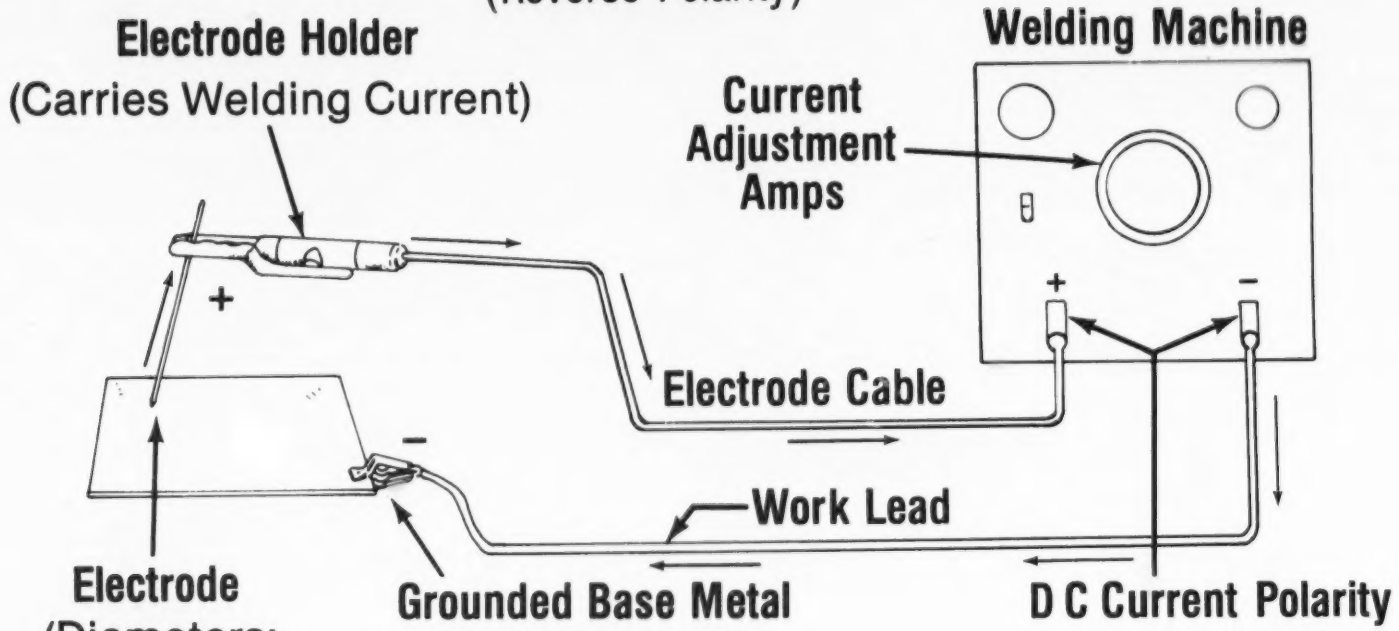
A. Hendrix, Laborn J. "Bud." *Fundamentals of Carpentry*, Stillwater, Oklahoma: State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center, and The Associated General Contractors of America, 1980.

B. Jefferson, T.B. *The Welding Encyclopedia*. Morton Grove, Illinois: Monticello Books, 1968.

C. *Symbols for Welding and Nondestructive Testing*. Miami, Florida: American Welding Society, Inc., 1979.

Welding Circuit

(Reverse Polarity)



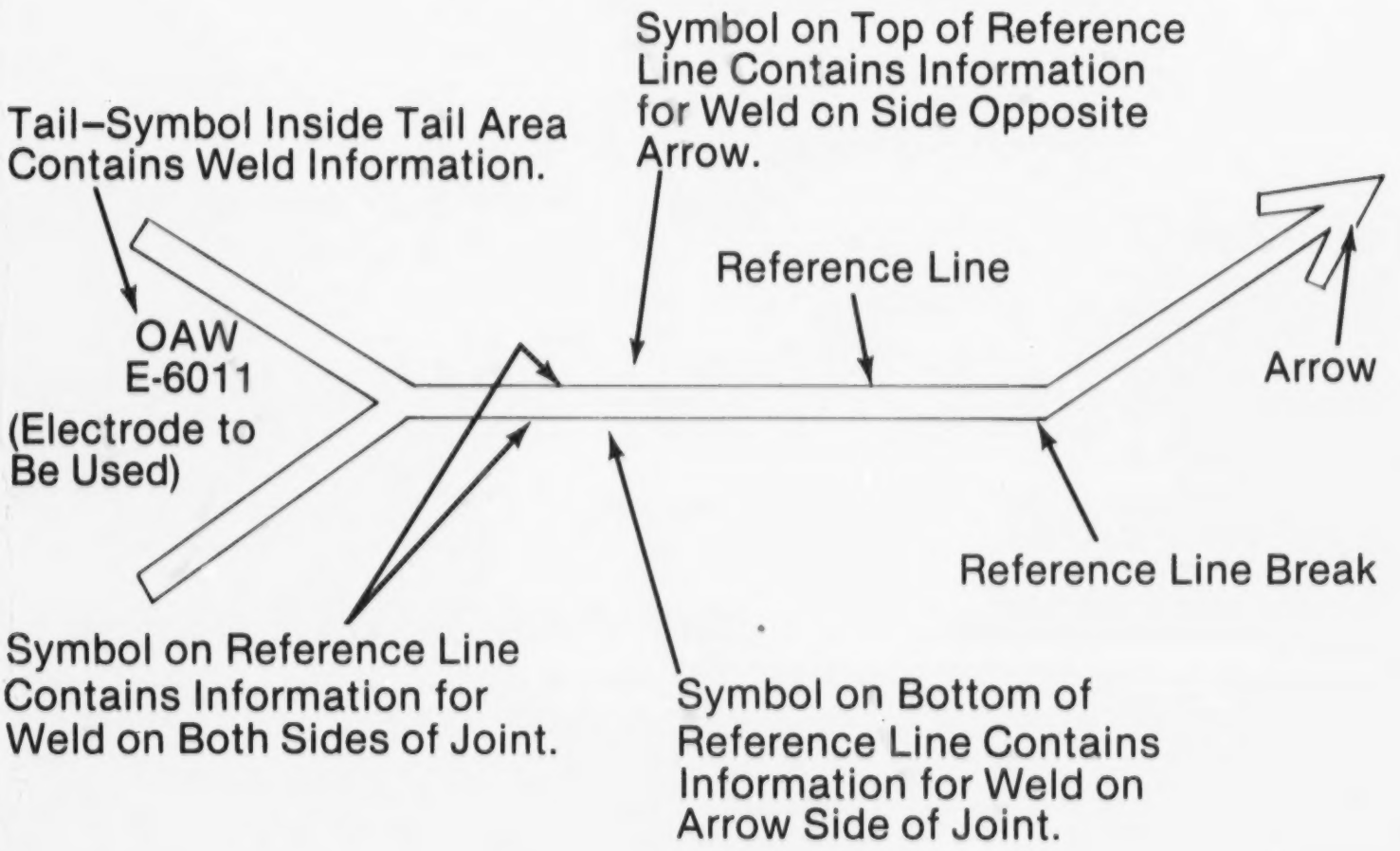
Reverse:

1. Electrode (+)
2. Current flows from base metal to electrode
3. Two-thirds heat at (+) electrode; one-third heat at (−) work

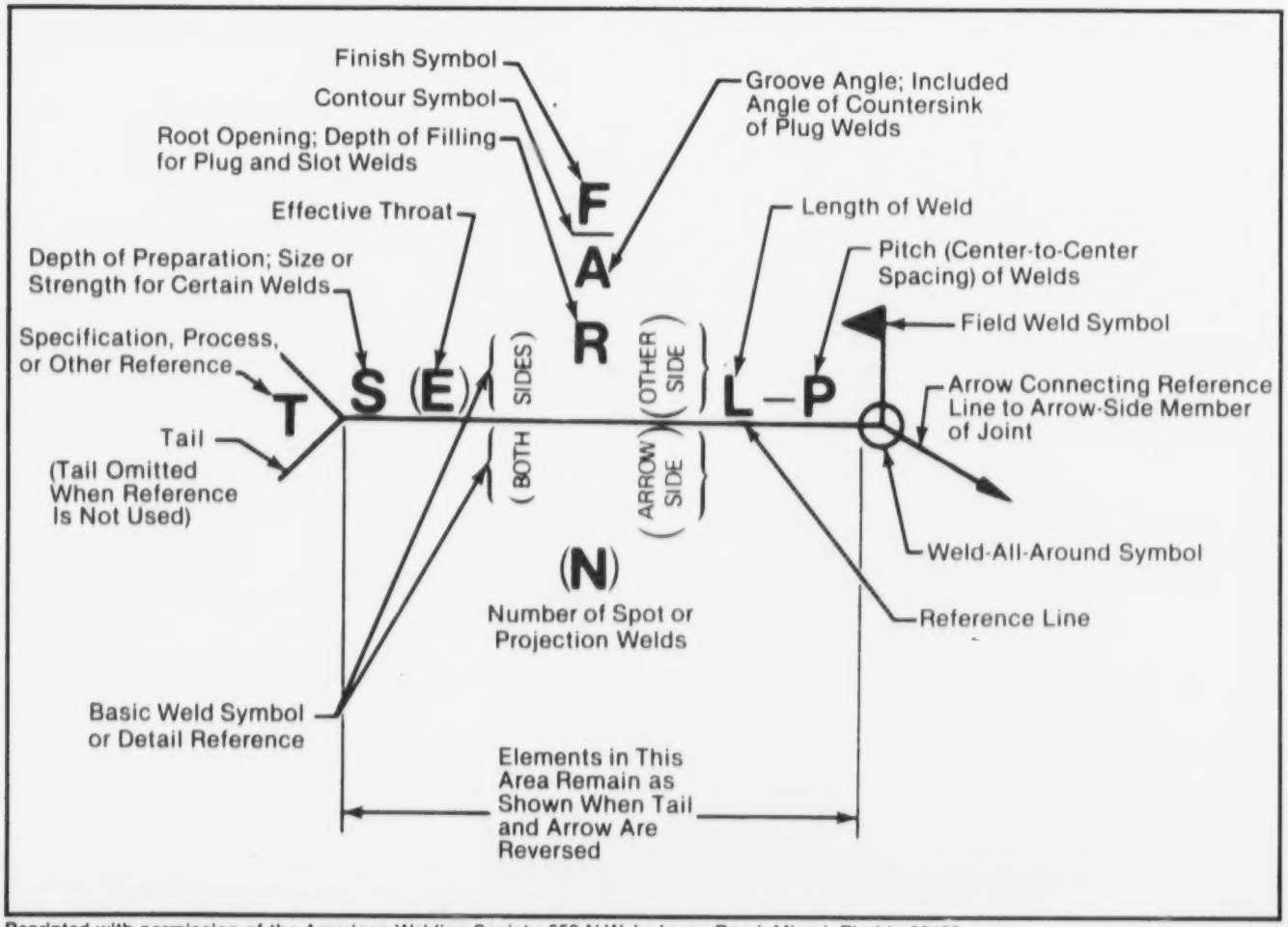
Straight:

1. Electrode (−)
2. Current flows from electrode to base metal
3. Two-thirds heat at (−) work; one-third heat at (+) electrode

Elements of Welding Symbols


Tail–Symbol Inside Tail Area Contains Weld Information.
Symbol on Top of Reference Line Contains Information for Weld on Side Opposite Arrow.
Reference Line
Arrow
OAW
E-6011
(Electrode to Be Used)
Reference Line Break
Symbol on Reference Line Contains Information for Weld on Both Sides of Joint.
Symbol on Bottom of Reference Line Contains Information for Weld on Arrow Side of Joint.

Standard Location of Welding Symbol Elements



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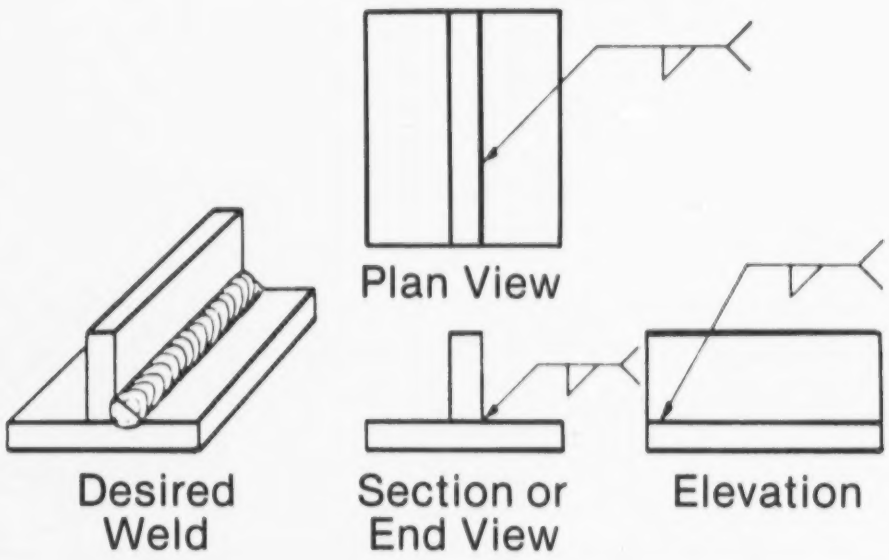
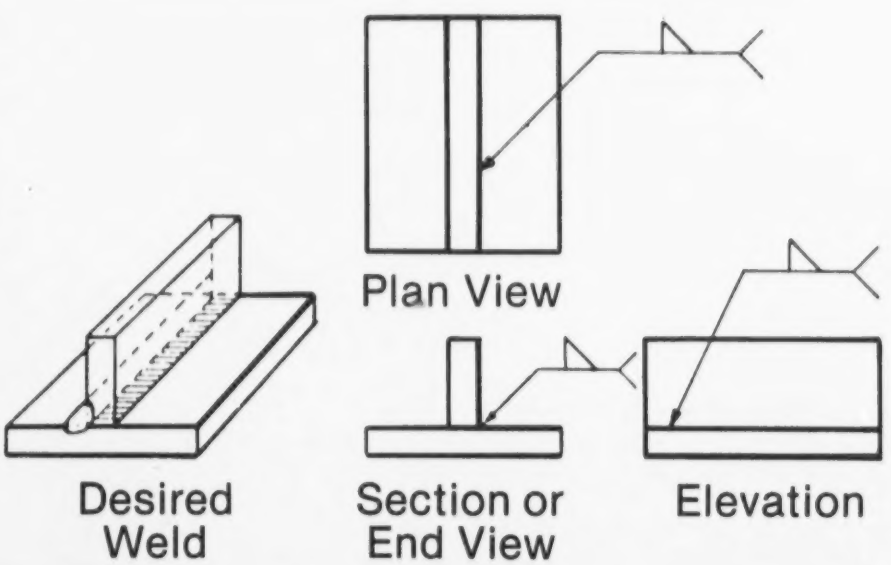
Application of Fillet Welding Symbol

Arrow Side of Fillet Welding Symbol

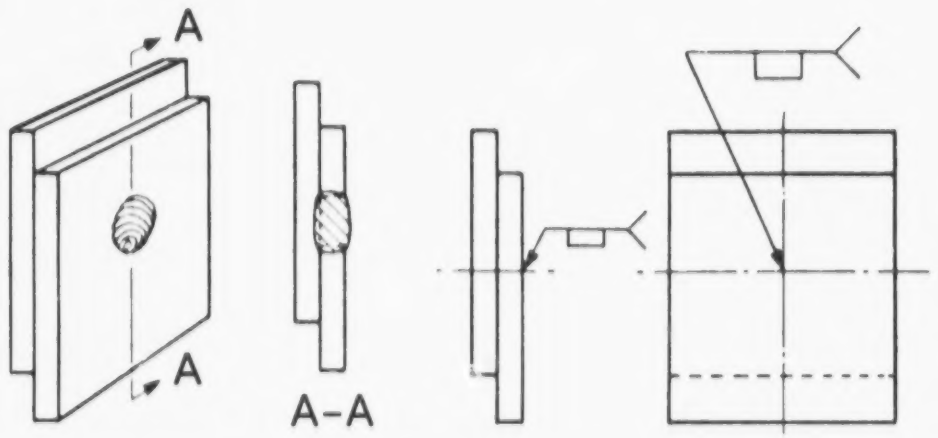


Other Side of Fillet Welding Symbol



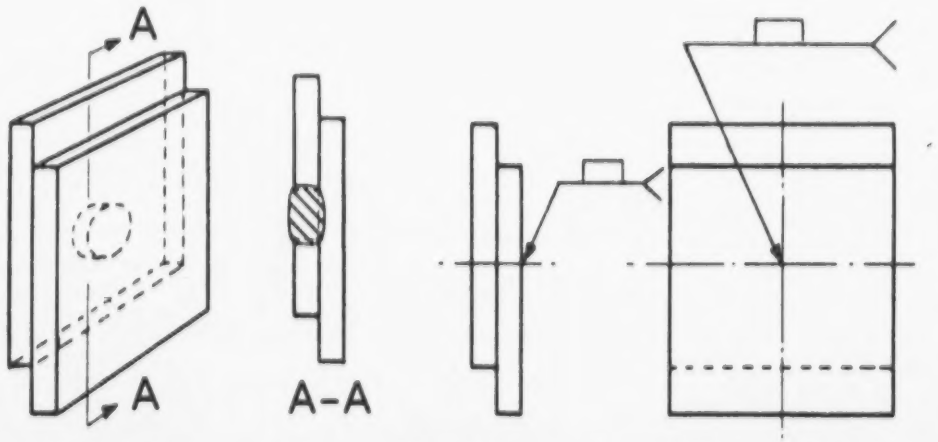
Application of Plug Welding Symbol

Arrow Side of Plug Welding Symbol



Desired Weld | Section or End View | Elevation

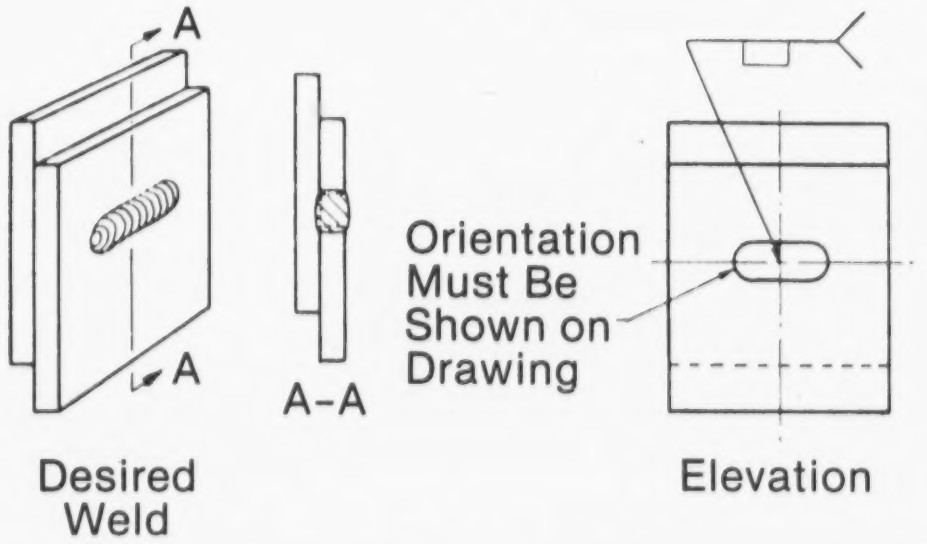
Other Side of Plug Welding Symbol



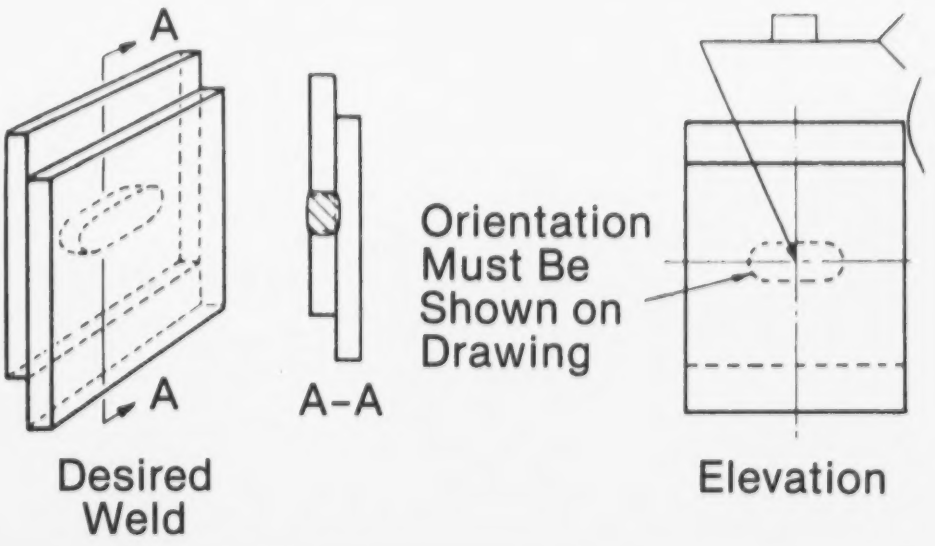
Desired Weld | Section or End View | Elevation

Application of Slot Welding Symbol

Arrow Side of Slot Welding Symbol



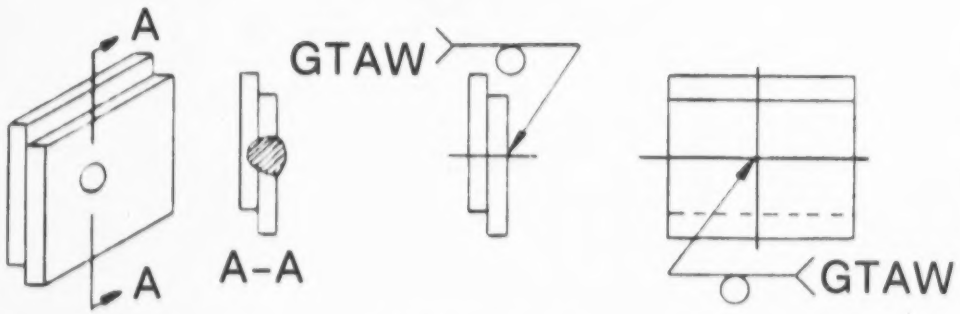
Other Side of Slot Welding Symbol



Application of Spot Welding Symbol

Arrow Side of Spot Welding Symbol

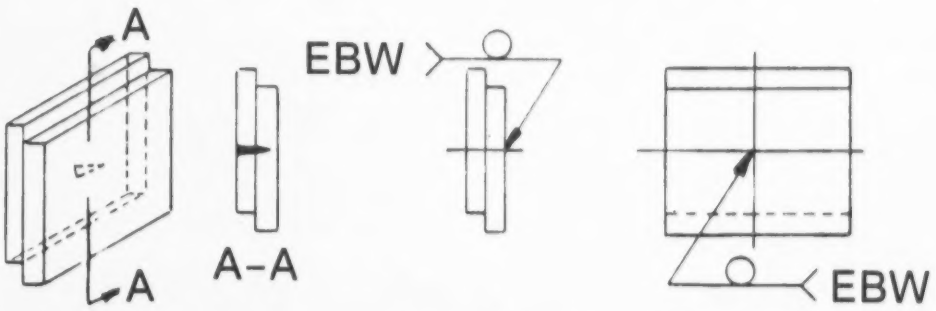
(Gas Tungsten-Arc Spot)



Desired Weld | Section or End View | Elevation

Other Side of Spot Welding Symbol

(Electron Beam Spot)

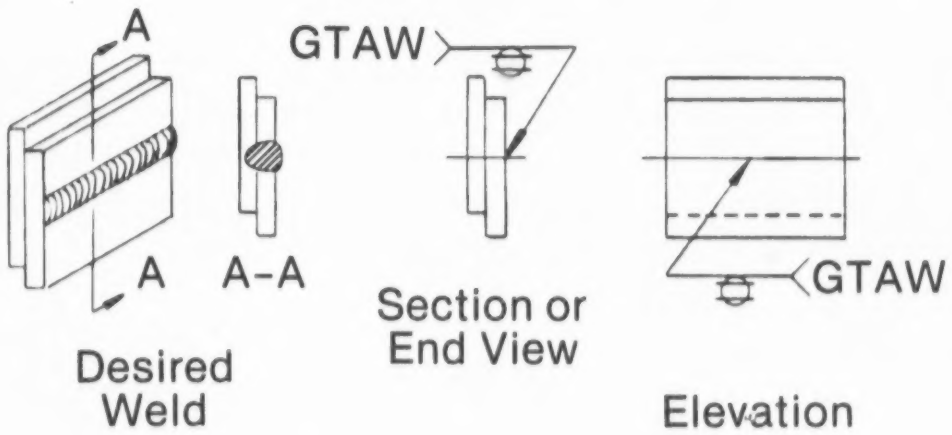


Desired Weld | Section or End View | Elevation

Application of Seam Welding Symbol

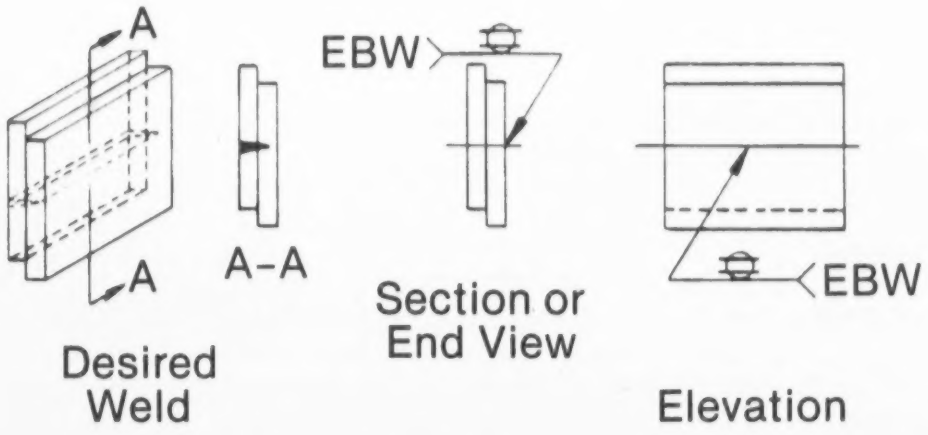
Arrow Side of Seam Welding Symbol

(Gas Tungsten-Arc Spot)



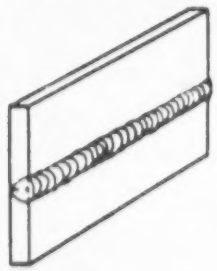
Other Side of Side Seam Welding Symbol

(Electron Beam Spot)



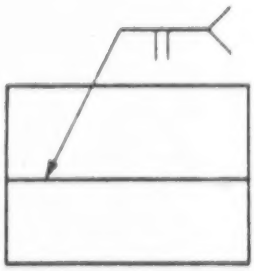
Application of Square-Groove Welding Symbol

Arrow Side of Square-Groove Welding Symbol



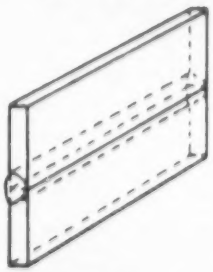
Desired Weld

Section or End View

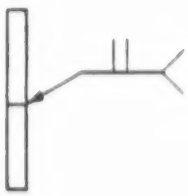


Elevation

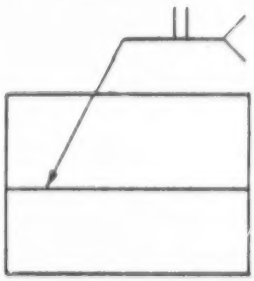
Other Side of Square-Groove Welding Symbol



Desired Weld

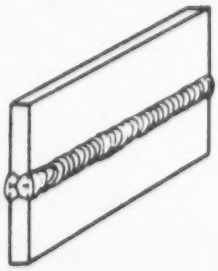


Section or End View

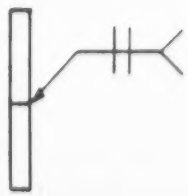


Elevation

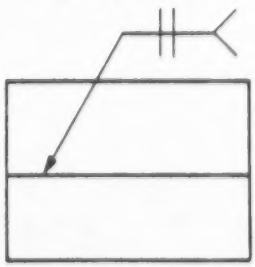
Both Sides of Square-Groove Welding Symbol



Desired Weld



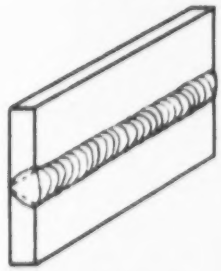
Section or End View



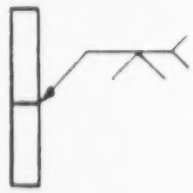
Elevation

Application of V-Groove Welding Symbol

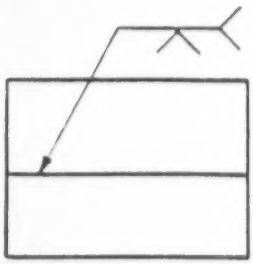
Arrow Side of V-Groove Welding Symbol



Desired Weld

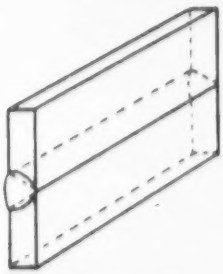


Section or End View

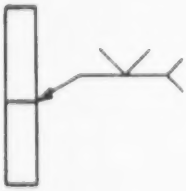


Elevation

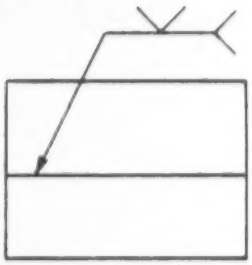
Other Side of V-Groove Welding Symbol



Desired Weld

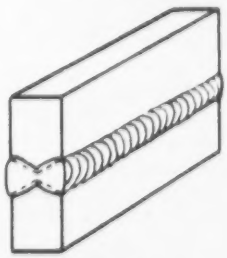


Section or End View

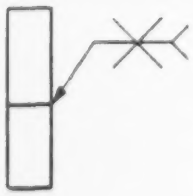


Elevation

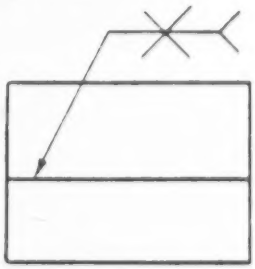
Both Sides of V-Groove Welding Symbol



Desired Weld



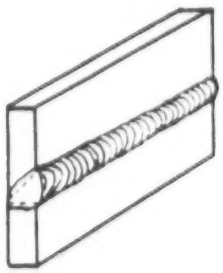
Section or End View



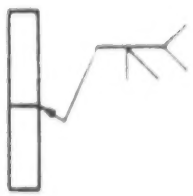
Elevation

Application of Bevel-Groove Welding Symbol

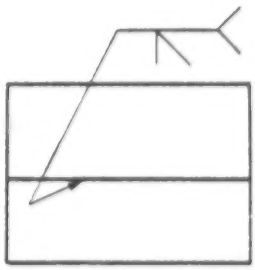
Arrow Side of Bevel-Groove Welding Symbol



Desired Weld

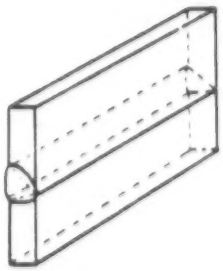


Section or End View

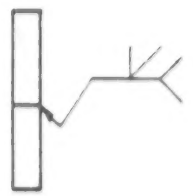


Elevation

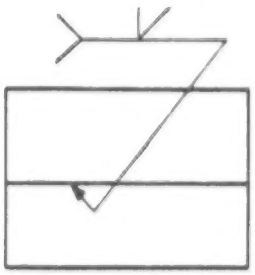
Other Side of Bevel-Groove Welding Symbol



Desired Weld

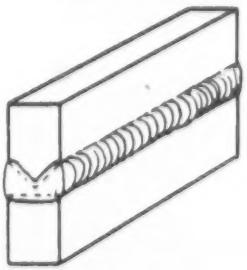


Section or End View

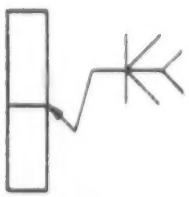


Elevation

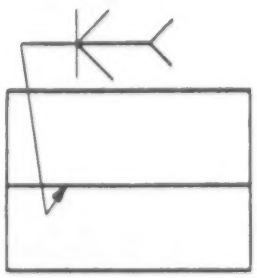
Both Sides of Bevel-Groove Welding Symbol



Desired Weld



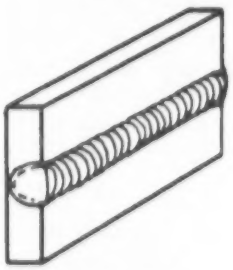
Section or End View



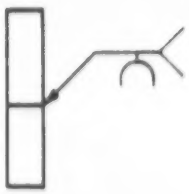
Elevation

Application of U-Groove Welding Symbol

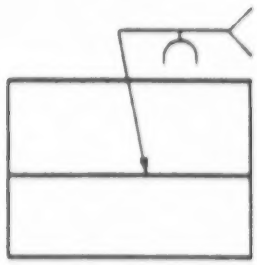
Arrow Side of U-Groove Welding Symbol



Desired Weld

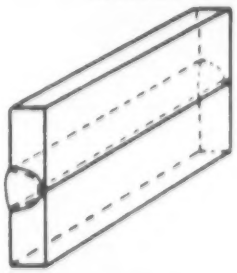


Section or End View

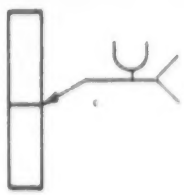


Elevation

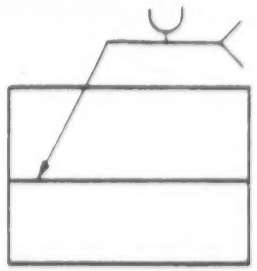
Other Side of U-Groove Welding Symbol



Desired Weld

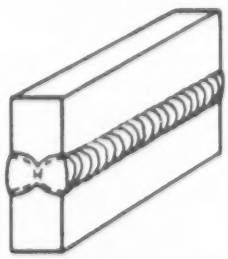


Section or End View

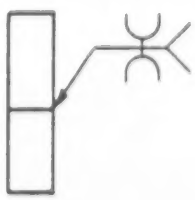


Elevation

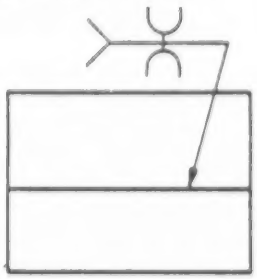
Both Sides of U-Groove Welding Symbol



Desired Weld



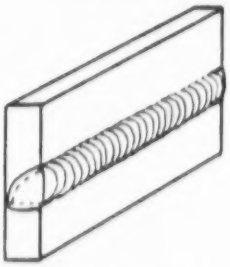
Section or End View



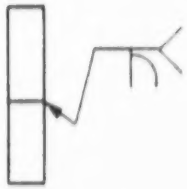
Elevation

Application of J-Groove Welding Symbol

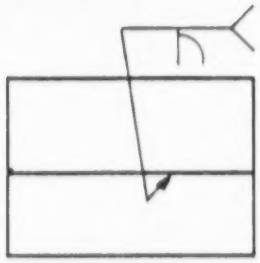
Arrow Side of J-Groove Welding Symbol



Desired Weld

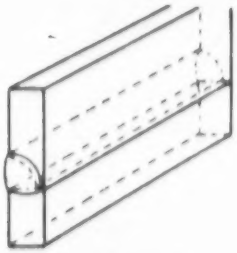


Section or End View

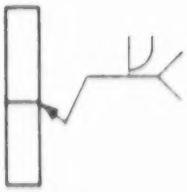


Elevation

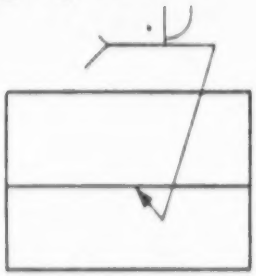
Other Side of J-Groove Welding Symbol



Desired Weld

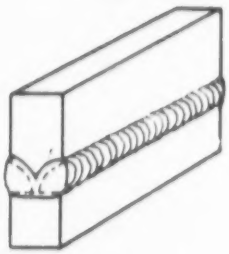


Section or End View

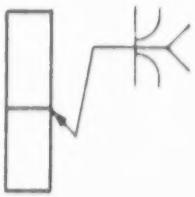


Elevation

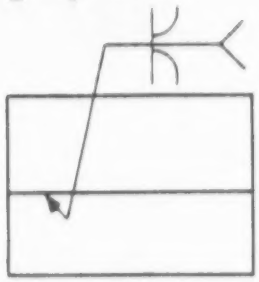
Both Sides of J-Groove Welding Symbol



Desired Weld



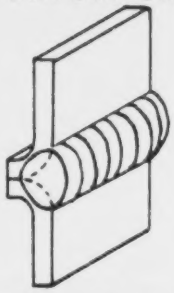
Section or End View



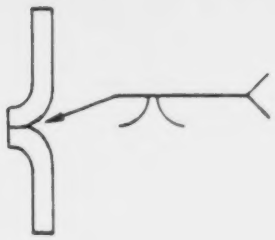
Elevation

Application of Flared V-Groove Welding Symbol

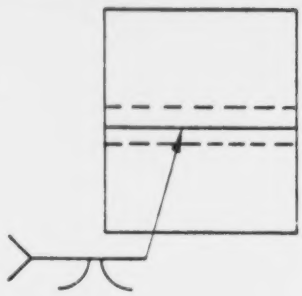
Arrow Side of Flared V-Groove Welding Symbol



Desired Weld

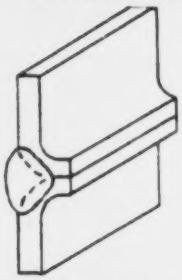


Section or End View

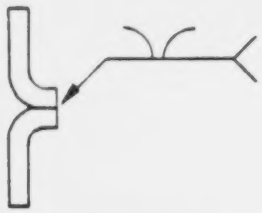


Elevation

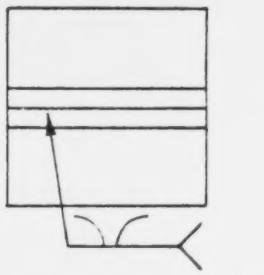
Other Side of Flared V-Groove Welding Symbol



Desired Weld

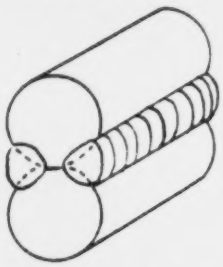


Section or End View

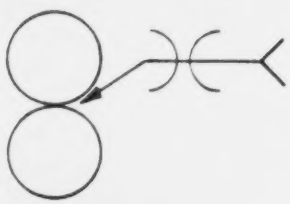


Elevation

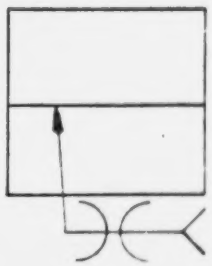
Both Sides of Flared V-Groove Welding Symbol



Desired Weld



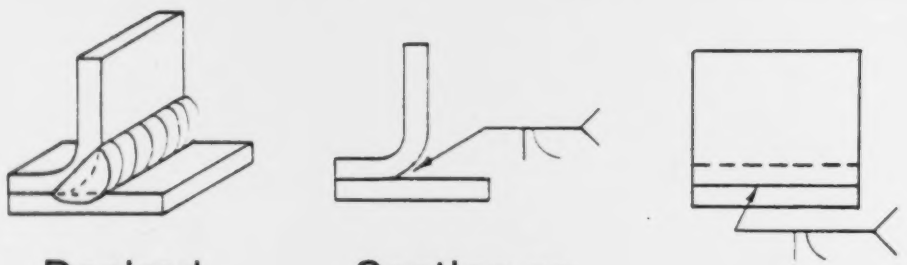
Section or End View



Elevation

Application of Flared Bevel-Groove Welding Symbol

Arrow Side of Flared Bevel-Groove Welding Symbol

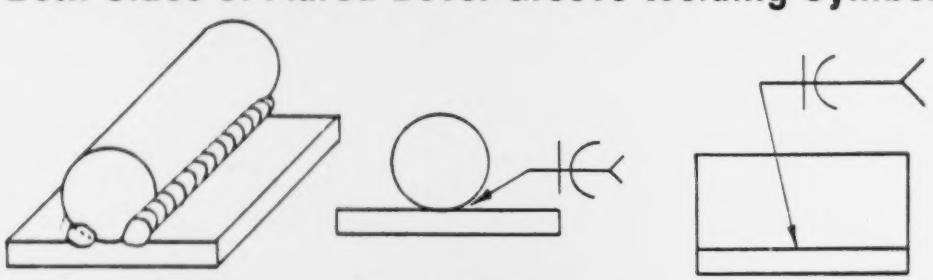


Desired Weld | Section or End View | Elevation

Other Side of Flared Bevel-Groove Welding Symbol

Desired Weld | Section or End View | Elevation

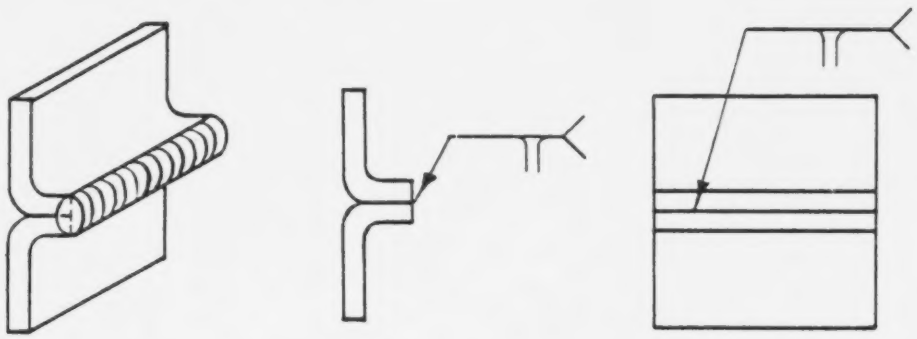
Both Sides of Flared Bevel-Groove Welding Symbol



Desired Weld | Section or End View | Elevation

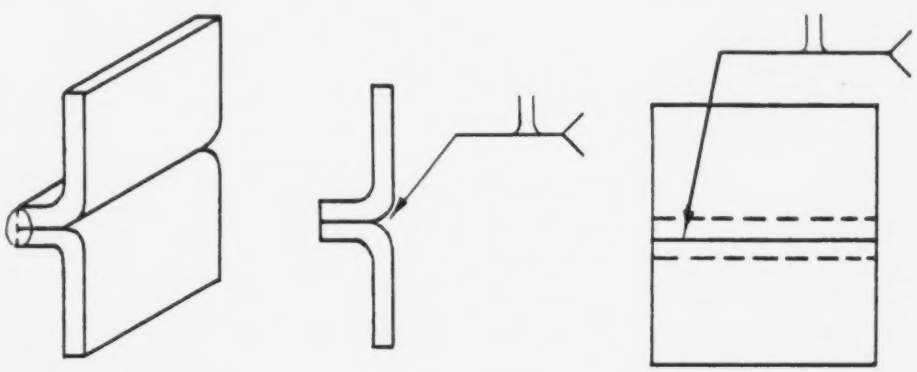
Application of Edge-Flange Welding Symbol

Arrow Side of Edge-Flange Welding Symbol



Desired Weld | Section or End View | Elevation

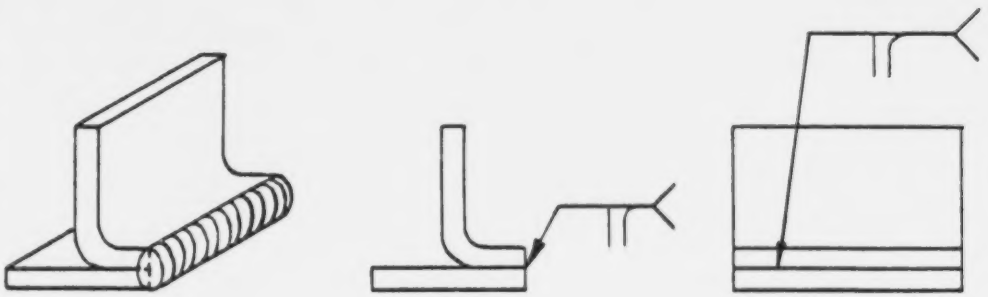
Other Side of Edge-Flange Welding Symbol



Desired Weld | Section or End View | Elevation

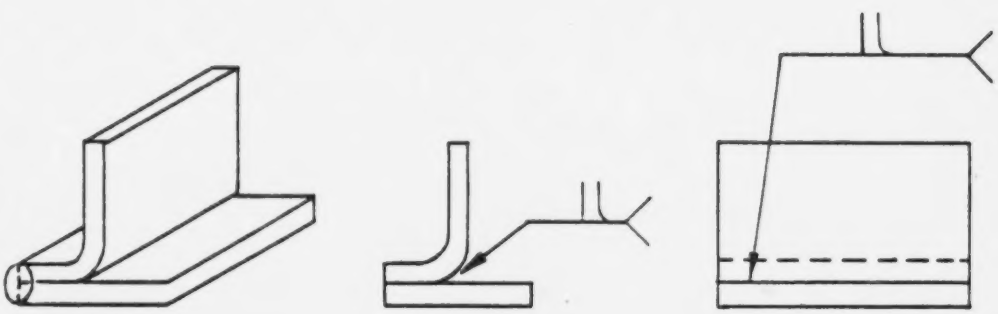
Application of Corner-Flange Welding Symbol

Arrow Side of Corner-Flange Welding Symbol



Desired Weld | Section or End View | Elevation

Other Side of Corner-Flange Welding Symbol



Desired Weld | Section or End View | Elevation

WELDING LAYOUT AND BASIC SKILLS
UNIT III

INFORMATION SHEET

I. Terms and definitions associated with welding layout and basic skills

A. **Arc** — Flow of current across a narrow gap, usually from tip of electrode to base metal

B. **Arc length** — Distance from end of electrode to point where arc makes contact with work surface

C. **Arc welding** — Joining of two or more pieces of metal by fusion process

(NOTE: Arc welding is sometimes referred to as shielded metal-arc welding, SMAW, or stick welding.)

D. **Bevel** — Angular cut made on the vertical edge of base metal to allow better weld penetration

E. **Butt joint** — Weld between two metal joints on the same plane

F. **Crater** — Depression at termination of weld

G. **Ductile** — Capable of being drawn or stretched

H. **Electrode** — Metal rod that conducts a current from electrode holder to base metal

(NOTE: The metal rod melts and deposits metal in a bead.)

I. **Flux** — Coating on outside of electrode; chemical used to promote fusion during welding process

J. **Fusion process** — Process of heating metal to a molten state and allowing it to cool

(NOTE: In arc welding, the heat is produced by the electric arc.)

K. **Gaseous shield** — Gas given off by melting of electrode flux

L. **Heat line (heat-affected zone)** — That part of base metal altered by heat from welding, brazing, or cutting operations

M. **Low-hydrogen electrode** — Electrode with low hydrogen content; used when cracking is a potential problem

N. **Malleable** — Capable of being worked into a different shape or form

O. **Pass** — Single longitudinal progression of a welding operation along a joint or weld deposit

P. **Penetration** — Distance from original surface of base metal to that point at which fusion ceases

INFORMATION SHEET

Q. **Polarity** — Condition of being positive (+) or negative (-), as the ends of a magnet or electrical mechanism

R. **Puddle** — Portion of a weld that is molten at the place heat is applied

S. **Rippled** — Lightly ruffled or covered with small waves

T. **Slag inclusion** — Nonmetallic porous material trapped in weld metal or between weld metal and base metal

U. **Wire core** — Metal center of electrode

II. Safety precautions to observe when welding

(NOTE: Observe OSHA safety rules.)

A. Do not look at arc or reflection without eye protection

B. Do not wear shield or helmet that is in bad condition

C. Do not chip slag without wearing safety goggles

D. Wear proper protective clothing

EXAMPLE: Welder's leather vest or jacket, long-sleeved shirt with collar and cuffs buttoned, leather gloves, high-topped shoes or boots

E. Do not strike an arc until you have taken all safety precautions

(NOTE: If you can see the metal or electrode, *do not* weld.)

F. Do not weld around combustible or flammable materials

G. Do not pick up hot metals with bare hands

H. Be sure that confined areas are properly ventilated

I. Disconnect plug before checking welding machine

J. Do not leave electrode holder on welding table or in direct contact with grounded metal

K. Do not use worn or frayed cables

L. Be sure that floor is dry; do not stand in water when welding

M. Keep work area clean

N. Keep tools and materials in proper locations

O. Dispose of electrode stubs properly

P. Do not wear frayed clothing

INFORMATION SHEET

III. Common tools and equipment used in arc welding (Figure 1)

A. Welding machine

B. Electrode holder with lead

C. Ground clamp with lead

D. Shield or helmet

E. Leather gloves

F. Chipping hammer

G. Welding goggles (safety goggles)

H. Wire brush

I. Electrode

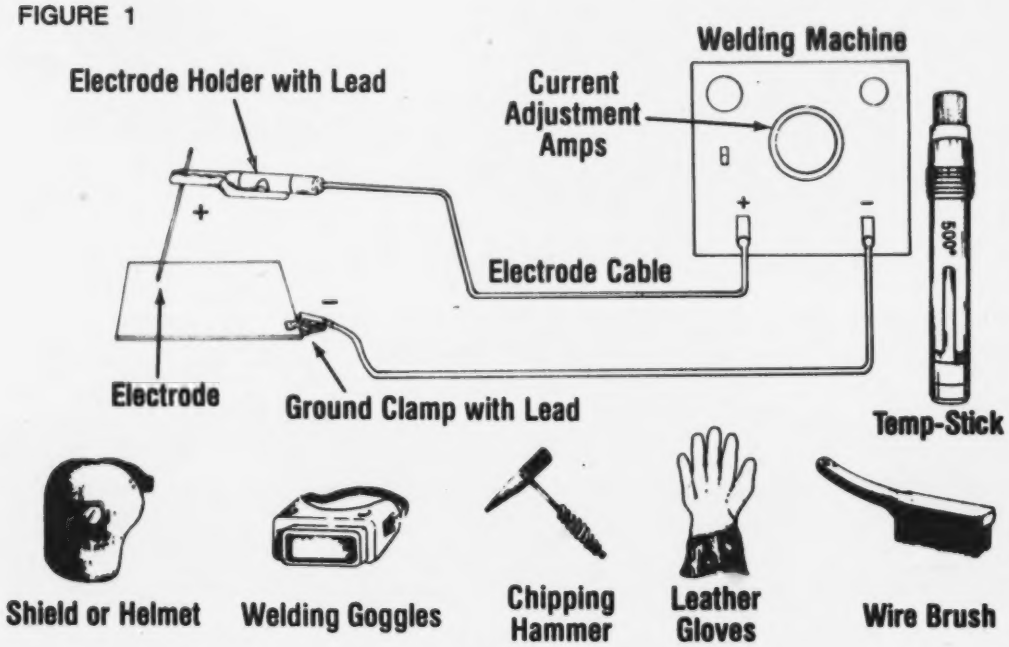
J. Protective clothing

K. Electrode cable

L. Temp stick

EXAMPLE:

FIGURE 1



INFORMATION SHEET

IV. Reverse and straight polarity

A. Reverse (+) — Current flows from base metal to electrode

B. Straight (-) — Current flows from electrode to base metal

(NOTE: Welding leads must connect to correct terminals if the machine has a polarity switch. Otherwise, a change in polarity is made by reversing leads on the terminals.)

V. Factors that determine correct polarity to use

A. Electrode

B. Type of flux on electrode

(NOTE: Use *Electrode Guidebook* to determine correct polarity for different electrodes.)

EXAMPLES: E-6010 (+) reverse polarity
E-6012 AC-DCSP (-) straight polarity
E-7018 AC-DCRP (+) reverse polarity
E-7024 AC-DCRP-SP (-) reverse or straight polarity

VI. Purposes of electrode flux

A. Stabilizing arc

B. Shielding molten puddle from air

C. Floating impurities out of puddle

D. Forming slag and slowing down cooling

E. Increasing welding speed

F. Improving quality of weld

G. Adding alloying elements to weld metal

VII. Factors to consider when selecting electrodes

A. Plans and specifications

B. Physical and chemical properties of base metal

C. Composition of base metal

D. Thickness and shape of base metal

E. Welding position

F. Welding current

G. Joint design and fit-up

H. Production efficiency and job conditions

INFORMATION SHEET

VIII. Effects of raising and lowering welding machine amperes

A. Raising amperes — Produces more heat; increases penetration

B. Lowering amperes — Produces less heat; decreases penetration

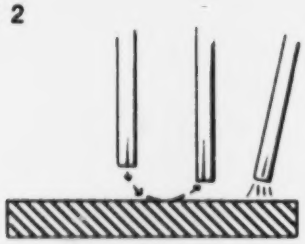
IX. Methods of striking an arc (Figures 2 and 3)

A. Scratching

(NOTE: The scratching method is similar to striking a match.)

EXAMPLE:

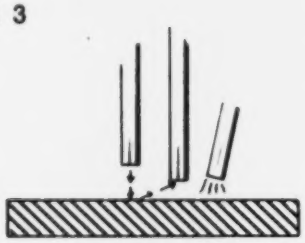
FIGURE 2



B. Tapping

EXAMPLE:

FIGURE 3



INFORMATION SHEET

X. Characteristics of proper arc length

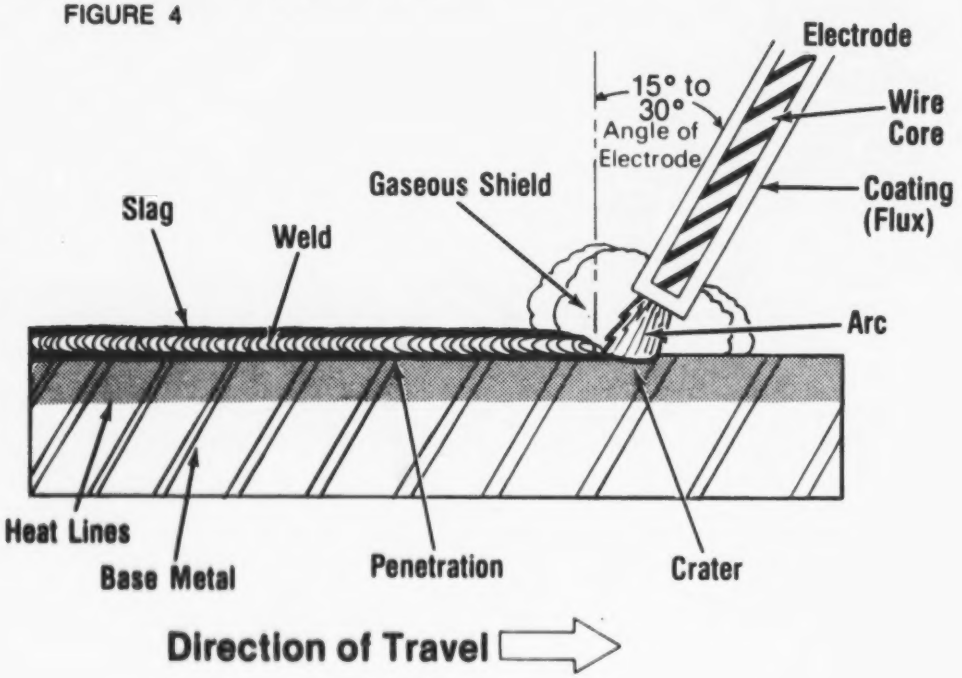
A. End of electrode same distance from base metal as diameter of electrode

EXAMPLE: When using 1/8-inch electrode, arc length should be 1/8-inch.

B. Arc length making steady hum at welder and frying sound at arc

XI. Parts of the welding process (Figure 4)

FIGURE 4



INFORMATION SHEET

XII. Descriptions of types of welds (Figures 5-7)

A. Fillet weld — Weld made in corner or angle formed by two pieces of metal with welded surfaces at approximately 90-degree angles to each other

EXAMPLE:

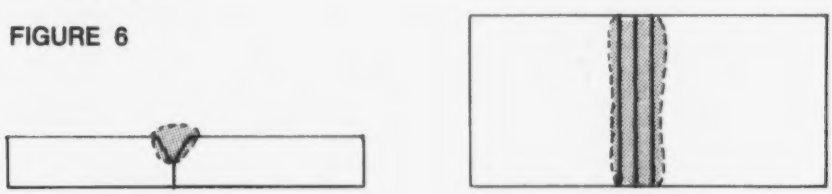
FIGURE 5

End View Top View

B. Groove weld — Weld made in groove formed by two beveled pieces of metal

EXAMPLE:

FIGURE 6

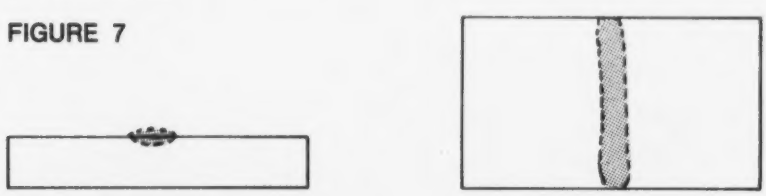


End View Top View

C. Bead weld — Weld made by one pass of electrode

EXAMPLE:

FIGURE 7



End View Top View

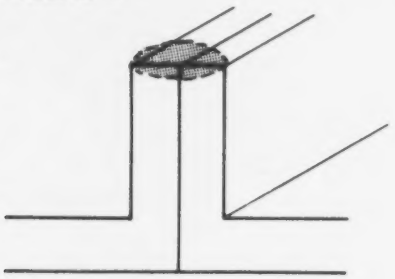
D. Tack weld — Temporary weld made to hold parts in alignment until final welds are made

INFORMATION SHEET

XIII. Types of weld joints (Figures 8-12)

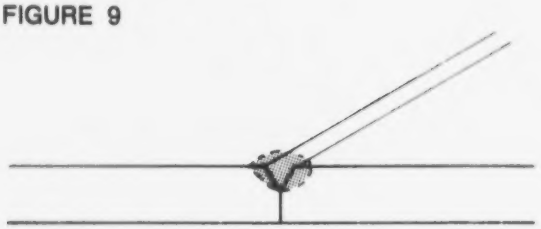
A. Edge

FIGURE 8



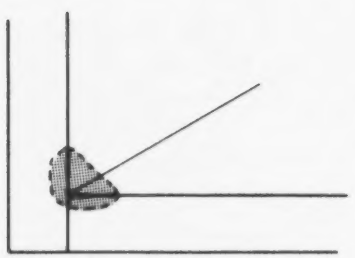
B. Butt

FIGURE 9



C. Corner

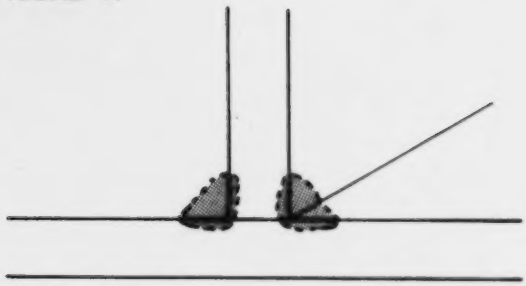
FIGURE 10



INFORMATION SHEET

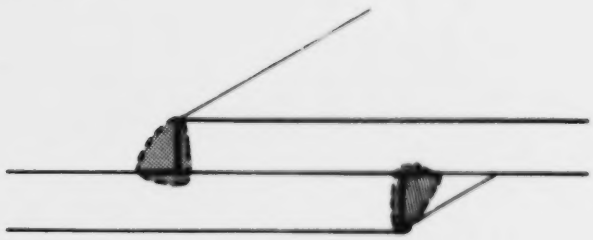
D. T

FIGURE 11



E. Lap

FIGURE 12

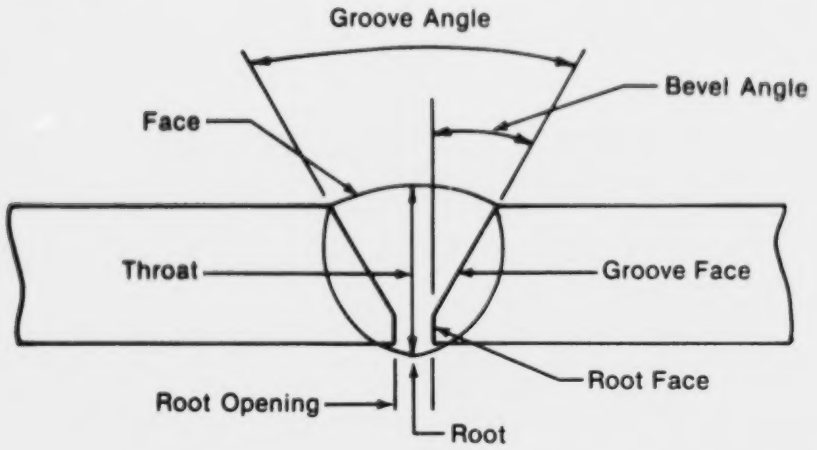


INFORMATION SHEET

XIV. Parts of groove and fillet welds (Figures 13 and 14)

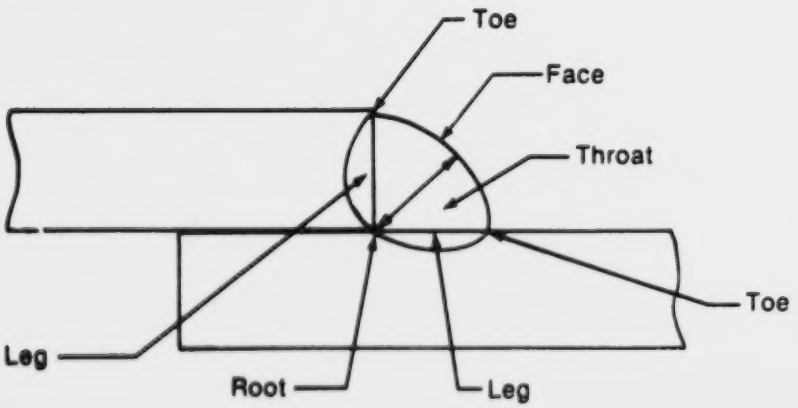
A. Groove weld

FIGURE 13



B. Fillet weld

FIGURE 14



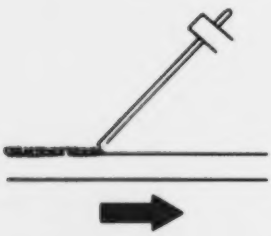
INFORMATION SHEET

XV. Positions used in arc welding (Figures 15-18)

A. Flat

EXAMPLE:

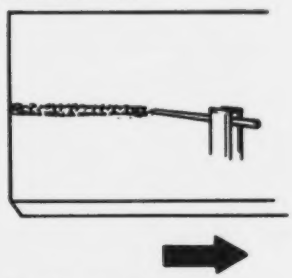
FIGURE 15



B. Horizontal

EXAMPLE:

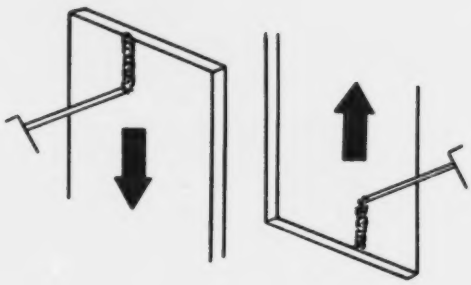
FIGURE 16



C. Vertical

EXAMPLE:

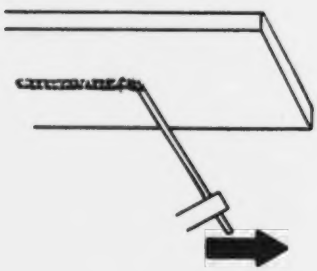
FIGURE 17



D. Overhead

EXAMPLE:

FIGURE 18



(NOTE: In vertical position, the bead may be started either from top or bottom, depending on characteristics of metal, plans, and specifications.)

INFORMATION SHEET

XVI. Reasons for poor welds

A. Incorrect machine adjustments

B. Too large or too small electrode

C. Improper movement of electrode

(NOTE: You must consider rate of travel and pattern of movement of the electrode.)

D. Improper angle of electrode

E. Improper preparation of base metal

F. Incorrect arc length

XVII. Types of electrode motions (rod manipulations) (Figures 19-21)

(NOTE: On a single-layer weld, to ensure proper fusion in the root zone, the arc may progress with a straight, forward motion or an oscillating motion, depending on size of joint to be filled.)

A. Small oscillating motion

B. Small circular motion

C. Back-and-forth motion with half circle

D. Figure-eight motion

E. Triangular motion

(NOTE: Most operators use all of these motions, depending upon type of seam, type of joint, size of weld, and position of weld.)

EXAMPLES:

FIGURE 19

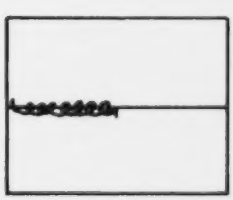


FIGURE 20

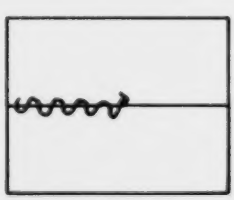
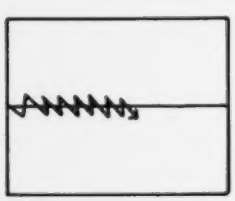


FIGURE 21



INFORMATION SHEET

XVIII. Characteristics of a good weld (Figures 22-25)

A. Smooth edge

B. Correct bead size

C. Even penetration (well-fused)

D. Even ripple

E. Clean, bright weld

F. Slight crown

EXAMPLES:

FIGURE 22

End View

Correct Bead Size

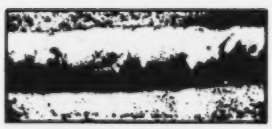
FIGURE 23

End View

Even Penetration (Well-Fused)

FIGURE 24

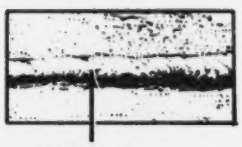
Top View



Even Ripple

FIGURE 25

Bottom View



Slight Crown

XIX. Elements of welding symbols and their descriptions

(NOTE: The term *weld symbol* indicates the type of weld. The term *welding symbol* includes type of weld and other information.)

A. **Reference line**

1. Top — Contains information for weld on side opposite arrow
2. Bottom — Contains information for weld on arrow side

B. **Arrow** — Points toward joint

INFORMATION SHEET

C. **Basic weld symbols** — Indicates type of weld

D. **Dimensions and other data** — Indicate size, length of weld; shown on same side of reference line as weld symbol

E. **Supplementary symbols** — Indicate contour, backing or spacer material, melt-through, field weld, weld all around

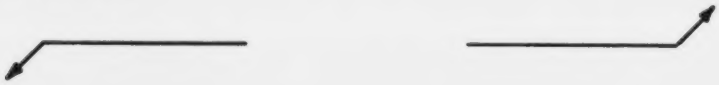
F. **Finish symbols** — Indicate method of finish

G. **Tail** — Includes specification, process, or other reference (Figure 26)

(NOTE: The welding symbol does not have a tail if there is not a specification, process, or other reference.)

EXAMPLES:

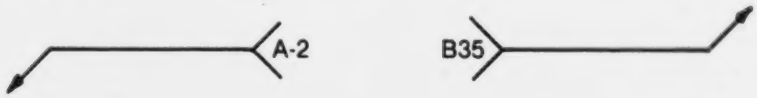
FIGURE 26



H. **Specification, process, or other reference** — Details information pertinent to weld; shown inside tail (Figure 27)

EXAMPLES:

FIGURE 27



XX. Symbols showing location of weld (Figures 28-30)

A. **Weld on arrow side of joint** — Shown by placing weld symbol beneath reference line

EXAMPLES:

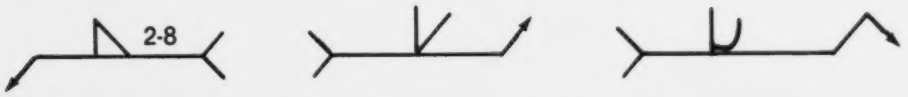
FIGURE 28

INFORMATION SHEET

B. **Weld on other side of joint** — Shown by placing weld symbol on top of reference line

EXAMPLES:

FIGURE 29



C. **Weld on both sides of joint** — Shown by placing weld symbols on both sides of reference line

EXAMPLE:

FIGURE 30

XXI. Basic weld symbols (Figure 31)

FIGURE 31

Groove							
Square	Scarf*	V	Bevel	U	J	Flared V	Flared Bevel

Fillet	Plug or Slot	Spot or Projection	Seam	Back or Backing	Surfacing	Flange	
						Edge	Corner

* Used for brazed joints only

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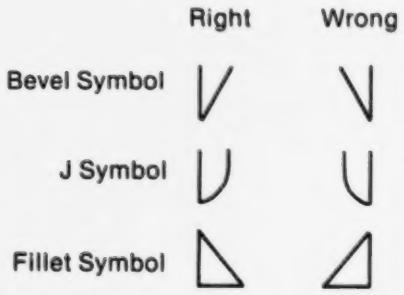
INFORMATION SHEET

XXII. Correct and incorrect drawing of symbols with one vertical side

(NOTE: Draw symbols that have one vertical side with that side always on the left. See Figure 32.)

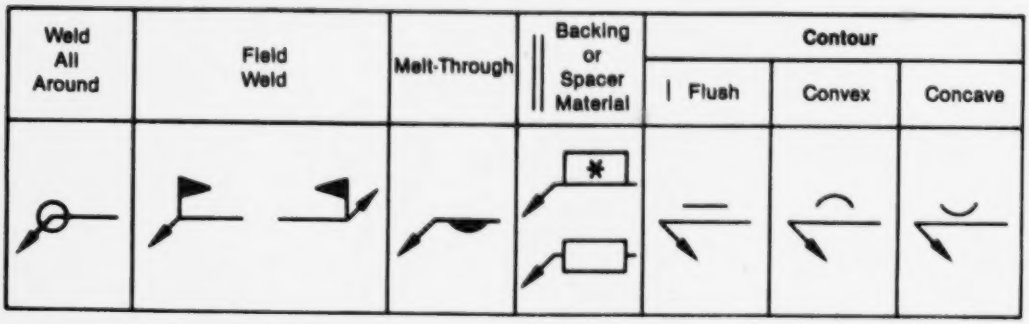
EXAMPLES: Fillet, bevel, and J-groove, flared bevel-groove, and corner-flange weld symbols

FIGURE 32



XXIII. Supplementary symbols (Figure 33)

FIGURE 33



INFORMATION SHEET

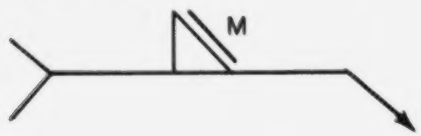
XXIV. Finish symbols used with contour symbols (Figures 34-38)

(NOTE: Finishing of welds, other than cleaning, is indicated by appropriate contour and finish symbols. These symbols indicate the method, not the degree, of finish.)

A. M — Machined

EXAMPLE:

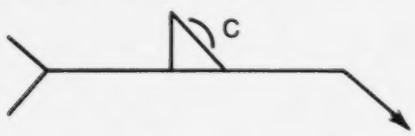
FIGURE 34



B. C — Chipped

EXAMPLE:

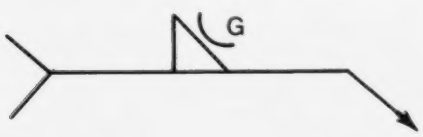
FIGURE 35



C. G — Ground

EXAMPLE:

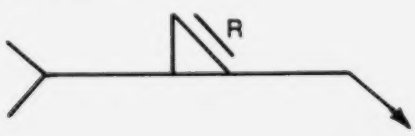
FIGURE 36



D. R — Rolled

EXAMPLE:

FIGURE 37

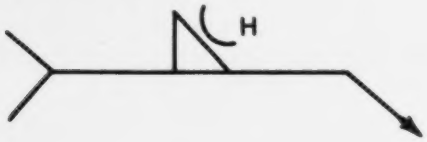


INFORMATION SHEET

E. H — Hammered

EXAMPLE:

FIGURE 38



WELDING LAYOUT AND BASIC SKILLS
UNIT III

JOB SHEET #1 — START, STOP, AND RESTART A BEAD

I. Equipment and materials

A. Piece of metal, 4 inches square, 1/4- to 3/8-inch thick

B. Welding machine

C. Electrode holder with lead

D. Ground clamp with lead

E. Shield or helmet

F. Leather gloves

G. Electrodes

H. Wire brush

I. Protective clothing

II. Procedure

A. Prepare metal for welding

B. Put on shield or helmet

C. Strike arc 1 inch from edge where bead is to begin (Figures 39 and 40)

FIGURE 39

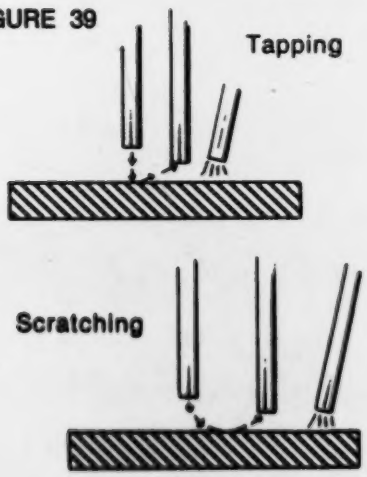
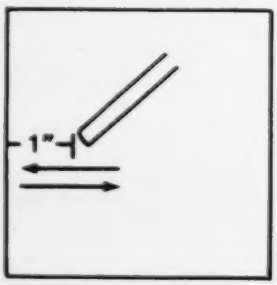


FIGURE 40



JOB SHEET #1

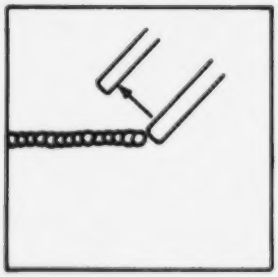
D. Move to edge when arc burns brightly, maintaining correct arc length; begin forming puddle

E. Move across metal 2 inches

F. Move electrode back through puddle, and lift up to stop bead (Figure 41)

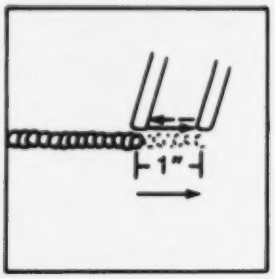
(NOTE: Moving electrode through puddle will prevent cracks from forming in the puddle.)

FIGURE 41



G. Strike arc about 1 inch in front of crater to restart (Figure 42)

FIGURE 42



H. Move back through crater when arc burns brightly, move back through crater, and continue the bead
(NOTE: Moving back through the crater is necessary in order for beads to blend with one another without a change in continuity.)

I. Clean work area; put away all equipment and materials

WELDING LAYOUT AND BASIC SKILLS
UNIT III

JOB SHEET #2 — CONSTRUCT A PAD WELD

I. Equipment and materials

A. Piece of metal, 4 inches square, 1/4- to 3/8-inch thick

B. Welding machine

C. Electrode holder with lead

D. Ground clamp with lead

E. Shield or helmet

F. Leather gloves

G. Electrodes

H. Safety goggles

I. Chipping hammer

J. Wire brush

K. Protective clothing

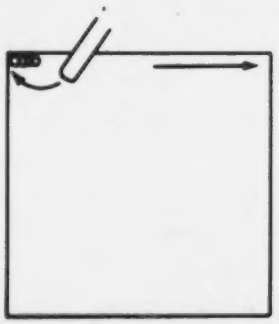
II. Procedure

A. Prepare metal for welding

B. Put on shield or helmet

C. Strike arc, and move to point to begin pad (Figure 43)

FIGURE 43



JOB SHEET #2

D. Lay a straight bead across the plate using an oscillating motion

(NOTE: When using an E-6011 electrode, you must manipulate the rod to run a bead. Ask your instructor to explain this process.)

E. Hold electrode at a 15- to 30-degree angle in direction of travel; to maintain correct arc length, lower electrode as rod burns away (Figure 44)

(NOTE: There should be 90 degrees on each side of the electrode. See Figure 45)

FIGURE 44

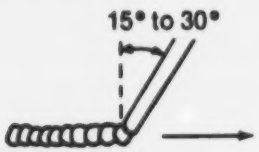
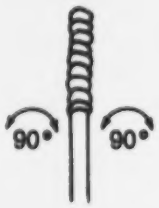


FIGURE 45



F. Move electrode steadily from left to right across pad

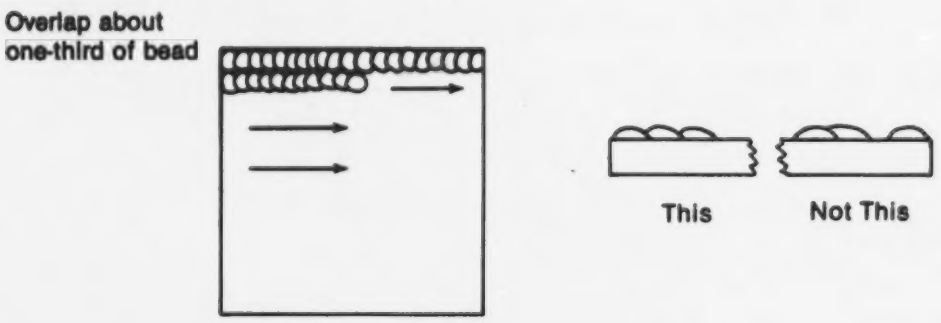
G. Clean slag from each bead before starting next one

CAUTION

If you remove your shield or helmet, always be sure to put on safety goggles.

H. Run beads, overlapping each bead until pad is full (Figure 46)

FIGURE 46



I. Let each bead cool until slag is black, before chipping

J. Run additional bead layers until desired thickness is obtained

K. Clean work area; put away all equipment and materials

WELDING LAYOUT AND BASIC SKILLS
UNIT III

JOB SHEET #3 — CONSTRUCT A BUTT WELD

I. Equipment and materials

A. Two metal pieces 3 by 6 inches, 1/4- to 3/8-inch thick

B. Welding machine

C. Electrode holder with lead

D. Ground clamp with lead

E. Shield or helmet

F. Leather gloves

G. Electrodes

H. Safety goggles

I. Chipping hammer

J. Wire brush

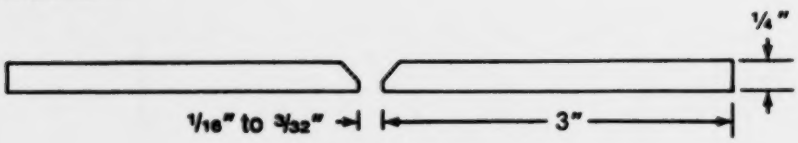
K. Protective clothing

II. Procedure

A. Prepare metal to be welded

(NOTE: If metal thickness is over 1/8-inch, the edges should be beveled. See Figure 47.)

FIGURE 47



B. Place two pieces of metal parallel to each other

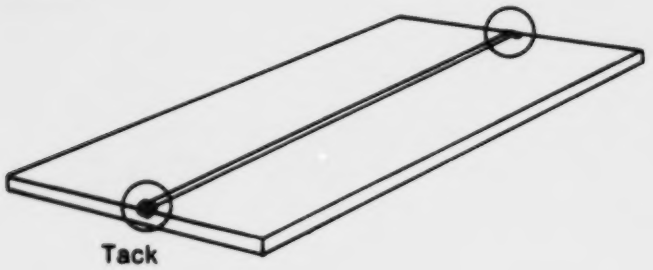
(NOTE: Leave a space of 1/16- to 3/32-inch between them.)

JOB SHEET #3

C. Put on shield or helmet

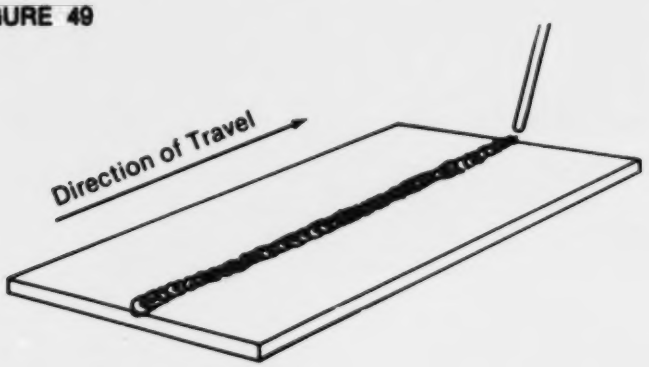
D. Strike an arc, and tack-weld pieces together at both ends (Figure 48)

FIGURE 48



E. Complete weld using a single pass (Figure 49)

FIGURE 49



F. Chip slag; brush the weld

CAUTION

If you remove your shield or helmet, always be sure to put on safety goggles.

G. Clean work area; put away all equipment and materials

WELDING LAYOUT AND BASIC SKILLS
UNIT III

TEST

NAME _____ SCORE _____

1. Match terms associated with arc welding to their correct definitions. Write the correct numbers in the blanks. Terms and definitions are continued on the next page.

_____a. Flow of current across a narrow gap, usually from tip of electrode to base metal

_____b. Process of heating metal to a molten state and allowing it to cool

_____c. Joining of two or more pieces of metal by fusion process

_____d. Depression at termination of weld

_____e. Single longitudinal progression of a welding operation along a joint or weld deposit

_____f. Metal rod that conducts a current from electrode holder to base metal

_____g. Angular cut made on the vertical edge of base metal to allow better weld penetration

_____h. Weld between two metal joints on the same plane

_____i. Portion of a weld that is molten at the place heat is applied

_____j. Metal center of electrode

_____k. Gas given off by melting of electrode flux

_____l. Coating on outside of electrode; chemical used to promote fusion during welding process

1. Arc welding
2. Bevel
3. Puddle
4. Crater
5. Wire core
6. Arc
7. Pass
8. Butt joint
9. Fusion process
10. Electrode
11. Flux
12. Gaseous shield

TEST

_____m. Nonmetallic porous material trapped in weld metal or between weld metal and base metal

_____n. The part of base metal altered by heat from welding, brazing, or cutting operations

_____o. Distance from original surface of base metal to that point at which fusion ceases

_____p. Electrode with low hydrogen content; used when cracking is a potential problem

_____q. Capable of being drawn or stretched

_____r. Distance from end of electrode to point where arc makes contact with work surface

_____s. Lightly ruffled or covered with small waves

_____t. Capable of being worked into a different shape or form

_____u. Condition of being positive (+) or negative (-), as the ends of a magnet or electrical mechanism

13. Heat line (heat-affected zone)
14. Penetration
15. Low-hydrogen electrode
16. Slag inclusion
17. Rippled
18. Malleable
19. Arc length
20. Ductile
21. Polarity

2. State ten safety precautions to observe when welding.

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

g. _____

h. _____

i. _____

j. _____

TEST

3. Select from the following list common tools and equipment used in arc welding. Write an "X" in the blank before each correct answer.

_____a. Shield or helmet
_____b. Safety goggles
_____c. Electrode
_____d. Oxyacetylene tank
_____e. Ground clamp with lead
_____f. Welding machine
_____g. Wire brush
_____h. Electrode holder with lead
_____i. Leather gloves
_____j. Chipping hammer
_____k. Protective clothing
_____l. Welding gauge

4. Distinguish between reverse and straight polarity. Write an "X" in the blank before the statement that represents reverse polarity.

_____a. Current flows from electrode to base metal
_____b. Current flows from base metal to electrode

5. Select from the following list factors that determine correct polarity to use. Write an "X" in the blank before each correct answer.

_____a. Electrode
_____b. Current
_____c. Type of flux on electrode
_____d. Color of electrode
_____e. Brand of electrode

6. Select from the following list purposes of electrode flux. Write an "X" in the blank before each correct answer.

_____a. Floating impurities out of puddle
_____b. Protecting electrode
_____c. Forming slag and slowing down cooling
_____d. Increasing welding speed
_____e. Shielding electrode from air
_____f. Stabilizing arc
_____g. Adding slag elements to weld metal
_____h. Improving quality of weld

TEST

7. List five factors to consider when selecting electrodes.

   a. _____

   b. _____

   c. _____

   d. _____

   e. _____

8. Describe effects of raising and lowering welding machine amperes.

   a. Raising amperes — _____

   _____

   b. Lowering amperes — _____

   _____

9. Name methods of striking an arc.

   a. _____

   b. _____

10. Select from the following list characteristics of proper arc length. Write an "X" in the blank before each correct answer.

    _____a. Arc length same size as bead

    _____b. Arc length making steady hum at welder and frying sound at arc

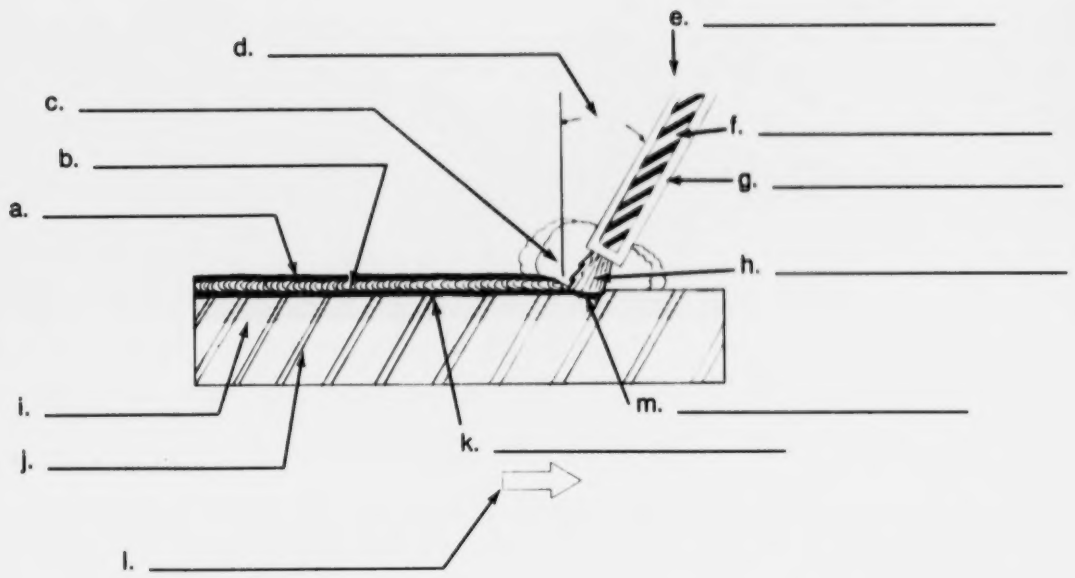
    _____c. End of electrode same distance from base metal as diameter of electrode

    _____d. End of electrode touching base metal

TEST

11. Identify parts of the welding process illustrated below. Write the correct names in the blanks.

Electrode	**Wire core**	**Angle of electrode**	**Base metal**
Coating (flux)	**Arc**	**(15 to 30 degrees)**	**Crater**
Penetration	**Weld**	**Heat lines**	**Slag**
Direction of travel	**Gaseous shield**		



TEST

12. Match types of welds to their correct descriptions. Write the correct numbers in the blanks.

_____a. Weld made by one pass of electrode

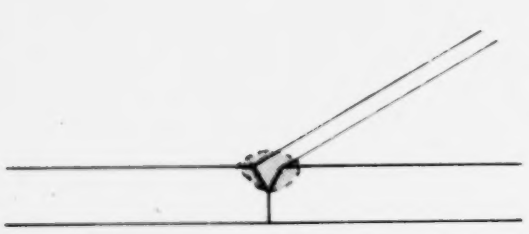
_____b. Temporary weld made to hold parts in alignment until final welds are made

_____c. Weld made in groove formed by two beveled pieces of metal

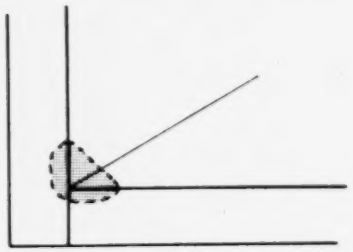
_____d. Weld made in corner or angle formed by two pieces of metal with welded surfaces at approximately 90-degree angles to each other

1. Tack weld
2. Bead weld
3. Fillet weld
4. Groove weld

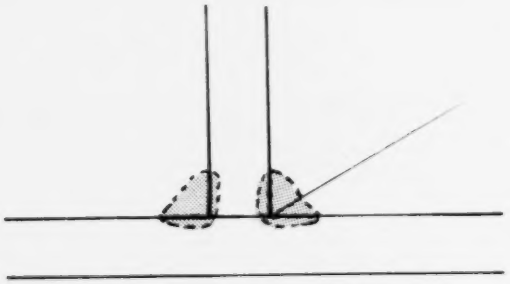
13. Label types of weld joints illustrated below and on the following page.



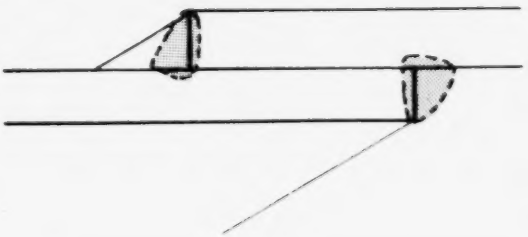
a. _____



b. _____

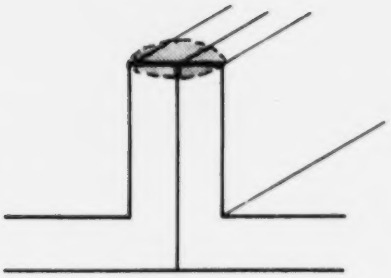


c. _____



d. _____

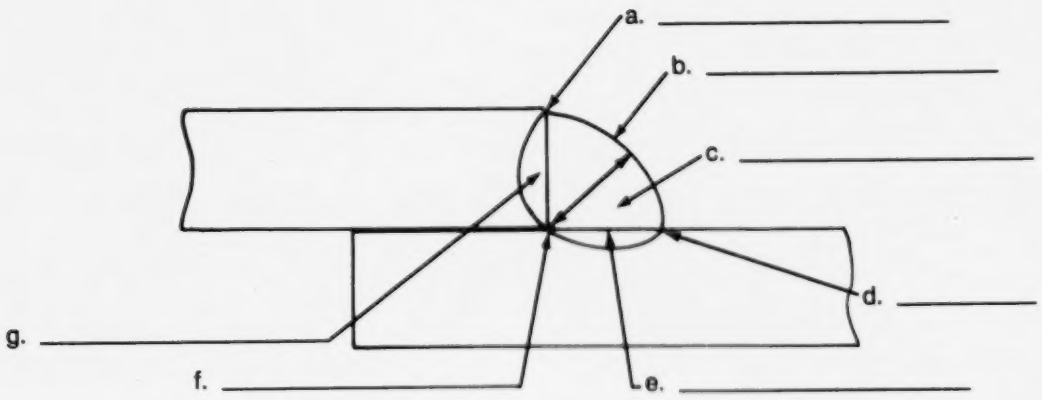
TEST



e. _____

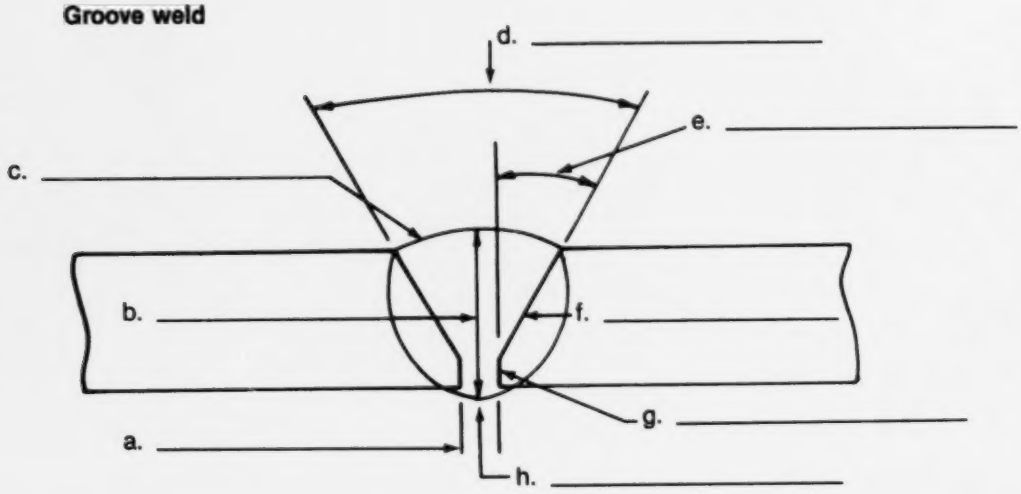
14. Label parts of groove and fillet welds illustrated below and on the following page.

Fillet weld



TEST

Groove weld



15. List positions used in arc welding.

a. _____

b. _____

c. _____

d. _____

16. List three reasons for poor welds.

a. _____

b. _____

c. _____

17. List four types of electrode motions (rod manipulations).

a. _____

b. _____

c. _____

d. _____

TEST

18. State three characteristics of a good weld.

a. _____

b. _____

c. _____

19. Match elements of welding symbols to their correct descriptions. Write the correct numbers in the blanks.

_____a. Includes specification, process, or other reference

_____b. Indicates type of weld

_____c. Contains information for weld on side opposite arrow

_____d. Indicates methods of finish

_____e. Indicates contour, backing or spacer material, melt-through, field weld, weld all around

_____f. Contains information for weld on arrow side

_____g. Points toward joint

_____h. Details information pertinent to weld; shown inside tail

_____i. Indicates size, length of weld; shown on same side of reference line as weld symbol

1. Reference line top
2. Reference line bottom
3. Arrow
4. Basic weld symbols
5. Dimensions and other data
6. Supplementary symbols
7. Finish symbols
8. Tail
9. Specification, process or other reference

20. Draw symbols showing location of weld. Any weld symbol may be used.

a. Weld on arrow side of joint

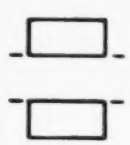
b. Weld on other side of joint

c. Weld on both sides of joint

TEST

21. Identify basic weld symbols. Write the correct names in the blanks.

Edge flange	**Flared V-groove**	**Square groove**	**Plug or slot**
Corner flange	**Flared bevel groove**	**Scarf groove**	**Spot or projection**
Surfacing	**U-groove**	**V-groove**	**Seam**
J-groove	**Bevel groove**	**Fillet**	**Back or backing**

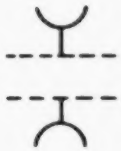


a. _____

b. _____

c. _____

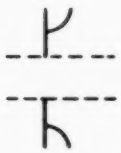
d. _____



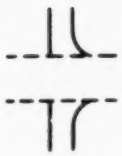
e. _____

f. _____

g. _____



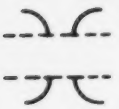
h. _____



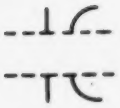
i. _____

TEST

j. _____



k. _____



l. _____

m. _____

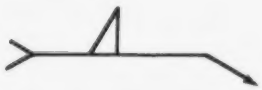
n. _____

o. _____

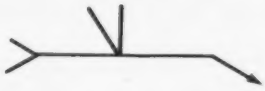
p. _____

TEST

22. Distinguish between correct and incorrect drawings of symbols with one vertical side. Write a "C" in the blank before each correct drawing.

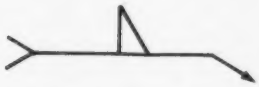


____a.

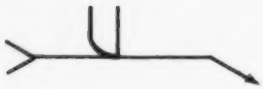


____d.

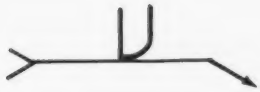
____b.



____e.



____c.

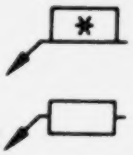


____f.

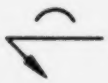
TEST

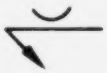
23. Identify supplementary symbols. Write the correct name in the blank.

Backing or spacer material **Flush contour** **Convex contour** **Field weld** **Melt-through** **Weld all around** **Concave contour**

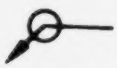


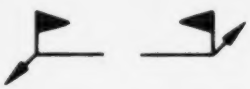
a. _____ b. _____



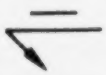


c. _____ d. _____





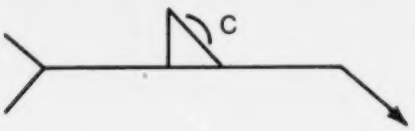
e. _____ f. _____



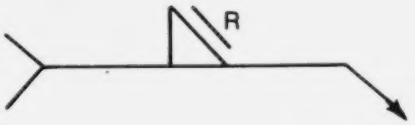
g. _____

TEST

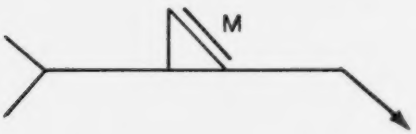
24. Interpret finish symbols used with contour symbols. Write the correct finish methods in the blanks.



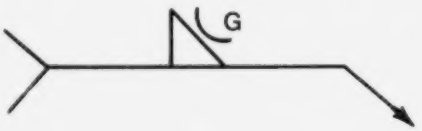
a. _____



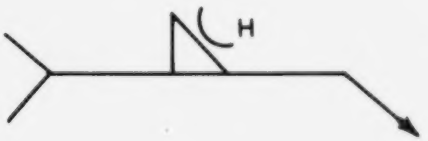
b. _____



c. _____



d. _____



e. _____

(NOTE: Test question 25 lists the job sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

25. Demonstrate the ability to

    a. Start, stop, and restart a bead.

    b. Construct a pad weld.

    c. Construct a butt weld.

WELDING LAYOUT AND BASIC SKILLS
UNIT III

ANSWERS TO TEST

1.

a. 6	g. 2	m. 16	s. 17
b. 9	h. 8	n. 13	t. 18
c. 1	i. 3	o. 14	u. 21
d. 4	j. 5	p. 15	
e. 7	k. 12	q. 20	
f. 10	l. 11	r. 19	

2. Answers should include any ten of the following

   a. Do not look at arc or reflection without eye protection
   b. Do not wear a shield or helmet that is in bad condition
   c. Do not chip slag without wearing safety goggles
   d. Wear proper protective clothing
   e. Do not strike an arc until you have taken all safety precautions
   f. Do not weld around combustible or flammable materials
   g. Do not pick up hot metals with bare hands
   h. Be sure that confined areas are properly ventilated
   i. Disconnect plug before checking welding machine
   j. Do not leave electrode holder on welding table or in direct contact with grounded metal
   k. Do not use worn or frayed cables
   l. Be sure that floor is dry; do not stand in water when welding
   m. Keep work area clean
   n. Keep tools and materials in proper locations
   o. Dispose of electrode stubs properly
   p. Do not wear frayed clothing

3. a, b, c, e, f, g, h, i, j, k

4. b

5. a, c

6. a, c, d, f, h

7. Answers should include any five of the following

   a. Plans and specifications
   b. Physical and chemical properties of base metal
   c. Composition of base metal
   d. Thickness and shape of base metal
   e. Welding position
   f. Welding current
   g. Joint design and fit-up
   h. Production efficiency and job conditions

ANSWERS TO TEST

8. Description should include

   a. Produces more heat; increases penetration
   b. Produces less heat; decreases penetration

9. a. Scratching
   b. Tapping

10. b, c

11. a. Slag
    b. Weld
    c. Gaseous shield
    d. Angle of electrode (15 to 30 degrees)
    e. Electrode
    f. Wire core
    g. Coating (flux)
    h. Arc
    i. Heat lines
    j. Base metal
    k. Penetration
    l. Direction of travel
    m. Crater

12. a. 2
    b. 1
    c. 4
    d. 3

13. a. Butt
    b. Corner
    c. T
    d. Lap
    e. Edge

14. **Fillet weld**

    a. Toe
    b. Face
    c. Throat
    d. Toe
    e. Leg
    f. Root
    g. Leg

    Groove weld

    a. Root opening
    b. Throat
    c. Face
    d. Groove angle
    e. Bevel angle
    f. Groove face
    g. Root face
    h. Root

15. a. Flat
    b. Horizontal
    c. Vertical
    d. Overhead

ANSWERS TO TEST

16. Answer should include any three of the following

    a. Incorrect machine adjustment
    b. Too large or too small electrode
    c. Improper movement of electrode
    d. Improper angle of electrode
    e. Improper preparation of base metal
    f. Incorrect arc length

17. Answer should include any four of the following

    a. Small oscillating motion
    b. Small circular motion
    c. Back-and-forth motion with half circle
    d. Figure-eight motion
    e. Triangular motion

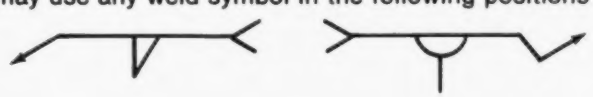
18. Answer should include any three of the following

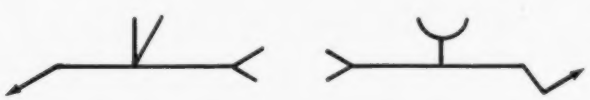
    a. Smooth edges
    b. Correct bead size
    c. Even penetration (well-fused)
    d. Even ripple
    e. Clean, bright weld
    f. Slight crown

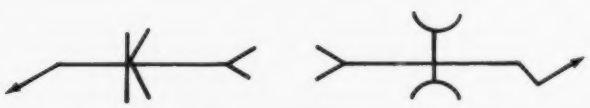
19.

a. 8	d. 7	g. 3
b. 4	e. 6	h. 9
c. 1	f. 2	i. 5

20. Student may use any weld symbol in the following positions

    a. 

    b. 

    c. 

ANSWERS TO TEST

21.
a. Plug or slot
b. Square groove
c. Edge flange
d. V-groove
e. U-groove
f. Surfacing
g. Fillet
h. J-groove
i. Corner flange
j. Scarf groove
k. Flared V-groove
l. Flared bevel groove
m. Seam
n. Spot or projection
o. Bevel groove
p. Back or backing

22. b, e, f

23.
a. Melt-through
b. Backing or spacer material
c. Convex contour
d. Concave contour
e. Weld all around
f. Field weld
g. Flush contour

24.
a. Chipped
b. Rolled
c. Machined
d. Ground
e. Hammered

25. Performance skills evaluated to the satisfaction of the instructor

OXYACETYLENE CUTTING
UNIT IV

UNIT OBJECTIVE

After completing this unit, the student should be able to set up, light, adjust, and use an oxyacetylene cutting outfit. The student will show this ability by completing job sheets and unit test with a minimum score of 80 percent.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to

1. Match terms associated with oxyacetylene cutting to their correct definitions.
2. State color codes for oxygen and acetylene.
3. Arrange in order stages in the oxyacetylene cutting process.
4. Identify the parts of an oxyacetylene cutting outfit.
5. Identify the parts of a torch body and cutting attachment.
6. State safety rules for working with oxyacetylene equipment.
7. Identify types of oxyacetylene cutting flames.
8. Distinguish between flashback and backfire.
9. Arrange in order steps to follow in case of flashback.
10. Select from a list causes of backfire.
11. Match common cutting-torch tips to their correct uses.
12. Identify a multiflame heating nozzle (rosebud) and tip.
13. Describe uses of a multiflame heating nozzle (rosebud).
14. Identify temperature sticks (temp-sticks).
15. Describe the selection and use of temperature sticks (temp-sticks).
16. Demonstrate the ability to
    a. Set up equipment for oxyacetylene cutting.
    b. Turn on, light, adjust to a neutral flame, and turn off oxyacetylene cutting equipment.

OBJECTIVE SHEET

c. Cut mild steel at a 90-degree angle, stop, and restart the cut.

d. Cut round stock.

e. Cut cable.

OXYACETYLENE CUTTING
UNIT IV

SUGGESTED ACTIVITIES

I. Unit contents

A. Objective sheet

B. Suggested activities

C. Transparency masters

1. TM #1 — Oxygen Regulator Gauges

2. TM #2 — Acetylene Regulator Gauges

D. Information sheet

E. Job sheets

1. Job Sheet #1 — Set Up Equipment for Oxyaetylene Cutting

2. Job Sheet #2 — Turn On, Light, Adjust to a Neutral Flame, and Turn Off Oxyacetylene Cutting Equipment

3. Job Sheet #3 — Cut Mild Steel at a 90-Degree Angle, Stop, and Restart the Cut

4. Job Sheet #4 — Cut Round Stock

5. Job Sheet #5 — Cut Cable

F. Test

G. Answers to test

II. Instructor's guide

A. Review unit and plan presentation.

B. Obtain materials to supplement unit.

1. Films

a. *Flame Cutting*. Color, 20 minutes, MacMillian Films, 1972. Available from MacMillian Films, 34 MacQuesten Parkway South, Mount Vernon, New York 10550, 914/664-5051.

(NOTE: This film provides step-by-step instructions for making straight-line cuts, cutting irregular shapes, beveling plate edges, and making circle cuts. It gives excellent instructions on freehand cutting with oxyacetylene cutting torch.)

b. *The Cutting Torch — Flame Cutting*. Color, 18 minutes, BFA Educational Media, 1972. Available from BFA Educational Media, 468 Park Avenue South, New York, New York 10016, 212/684-5910.

(NOTE: This film covers the many aspects of tip selection and the procedures for using the torch.)

(NOTE: These films are available on a free-loan basis to Oklahoma teachers from the Oklahoma State Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074. Out-of-state teachers must order from the addresses listed above.)

c. *Don't Push Your Luck*. Color, 12 minutes, Harvest Films, 1978. Available from Harvest Films, Inc., 309 5th Avenue, New York, New York 10016, 212/648-7950.

(NOTE: Bill Frank, the actual victim, recreates his real-life blinding accident. He delivers to employees a powerful safety message on face and eye protection.)

2. Slide/cassette programs and filmstrips

a. *There's Something in the Air*. Thirty slides with cassette, National Safety Council, n.d. Available from National Safety Council, P.O. Box 11933, Chicago, Illinois 60611, 312/527-4800.

(NOTE: This program tells workers how to protect themselves from contaminated air — fogs, mists, fumes, gases, smokes, sprays, and vapors — that could be harmful to their lungs.)

b. *Oxyacetylene Cutting Explained*. Two color filmstrips, 2 cassettes, 12 to 13 minutes each, Bergwall Productions, Inc., n.d. May be purchased from Bergwall Productions, 839 Steward Avenue, P.O. Box 238, Garden City, New York 11530. Call toll-free 800/645-3565.

(NOTE: Part 1, *Setting Up Equipment*, explains cutting operation: cutting tip, attaching tip to torch body, lighting and testing flame, purging the line and shutting down the unit. Part 2, *Specialized Oxyacetylene Cutting*, demonstrates torch angle, correct cutting procedure, lighting and testing the flame, cutting thin and heavy stock, chamfering, constructing and using guide for cutting a circle, and piercing stock.)

3. Competency profiles

(NOTE: A master of the competency profile for this book is provided at the front of the instructor edition. You may duplicate the profile and distribute it to students as needed.)

SUGGESTED ACTIVITIES

4. Gather equipment and materials for job sheet demonstrations.

5. Get color flame charts from welding supplier to show types of flames.

6. Contact local welding supplier for materials on cutting techniques, pressurized gas, safety equipment, and other items of interest.

C. Introduce unit by pointing out to students the versatility of the cutting torch for all types of metal construction and repair.

- Give examples of the uses of the cutting torch in commercial construction.

- Explain that people skilled with a cutting torch and in arc welding obtain well-paying jobs.

D. Provide students with objective sheet.

E. Discuss unit and specific objectives.

- Emphasize to students that the major thrust of the unit is to learn how to use the cutting torch safely and skillfully.

- Point out briefly what the main emphasis of each objective is and how all of the objectives build on each other to provide the knowledge and skills needed to accomplish the unit objective.

F. Provide students with information and job sheets.

G. Discuss information and job sheets.

1. Discuss terms and definitions associated with oxyacetylene cutting. Use Information Sheet, Section I, and an actual oxyacetylene cutting rig.

   - Bring the oxyacetylene cutting rig into the classroom to illustrate some of the terms.

2. Discuss the color codes for oxygen and acetylene; use Information Sheet, Section II. Also discuss characteristics of the gases.

   - Release some oxygen into the classroom air to show students that oxygen is colorless and odorless.

   - Perform the following demonstration to emphasize that oxygen supports and intensifies combustion.

SUGGESTED ACTIVITIES

a. Position a small burning candle on a table.

b. Set a glass container over the candle; the candle will burn out when the oxygen trapped in the container is used up.

c. Relight the candle.

d. Fill the container with oxygen from the torch, maintaining as good a seal as possible with your hand.

e. Set the oxygen-filled container down over the lighted candle quickly to illustrate how the high concentration of oxygen intensifies the flame.

3. Discuss the cutting process. Use Information Sheet, Section III.

- Emphasize to students that the preceding demonstration showed how oxygen can intensify flame temperature.
- Remind students that flame temperatures range from 5600°F to 6300°F.
- Perform a cutting demonstration to show how the molten metal is blown out by the pressure of the oxygen.

4. Discuss the parts of the oxyacetylene cutting equipment. Use Information Sheet, Section IV; Transparencies #1 and #2; and the actual equipment.

- Use unassembled equipment when starting this discussion, thereby demonstrating the process in Job Sheet #1 as the equipment is put together and each part is explained.
- Stress to the students the importance of knowing all of the parts of the cutting rig and their proper names.
- Show students the proper way to hold a flint lighter and to strike a spark.
- Stress the importance of always checking the lens of the cutting goggles or shaded face shield.

EXAMPLE: Recommended shade numbers for oxygen cutting

3 or 4 — Metal up to 1 inch thick
4 or 5 — Metal 1 inch to 6 inches thick
5 or 6 — Metal 6 inches thick and over

SUGGESTED ACTIVITIES

5. Use Information Sheet, Section V, and actual torches to discuss parts of a torch body and cutting attachment; explain the purpose of each part.

6. Discuss safety precautions for oxyacetylene cutting. Use Information Sheet, Section VI, as well as the actual cutting rig.

   - Review Job Sheet #1, emphasizing safety precautions as you work through the procedures.

   - Emphasize that the oxyacetylene cutting rig is potentially one of the most dangerous pieces of equipment in the shop, but it is safe if it is cared for and used properly.

7. Discuss and demonstrate the types of oxyacetylene flames. Use Section VII of the Information Sheet and actual torch flames.

   - Show films on flame cutting.

   - Explain how to recognize the different oxyactylene flames and how to adjust the torch to the desired flame.

   - Allow each student to adjust the lighted torch after you have demonstrated how to adjust the lighted torch to the various types of flames.

8. Use Information Sheet, Section VIII, to discuss flashback and backfire.

9. Use Information Sheet, Section IX, to discuss steps to follow in case of flashback.

   - Require students to know these steps in correct order before they are allowed to operate a torch.

   - Explain the logic of the steps as they are performed.

   - Remind the students that check valves become a valuable investment in the event of a flashback.

10. Discuss causes of backfire. Use Information Sheet, Section X.

    - Stress that should a torch backfire, the problem must be analyzed and corrected before continued use.

    - Stress to students that even if they as operators are at fault, backfire must be reported to the instructor immediately so that corrections can be made.

11. Use Information Sheet, Section XI, to discuss cutting-torch tips and their uses.
    - Show sample tips and how to install and use them.
    - Emphasize uses in the welding trade, such as where specific metals, tips, and rods might be used.
12. Use Information Sheet, Sections XII and XIII, to discuss multiflame heating nozzles and their uses.
13. Use Information Sheet, Sections XIV and XV, to discuss temp-sticks and their use.
14. Provide students with remaining job sheets and demonstrate the procedures.
15. Allow students to practice procedures.

H. Review unit.

I. Give test.

J. Critique test and discuss in class.

K. Reteach and retest as required.

L. Complete appropriate sections of competency profiles.

III. Unit references

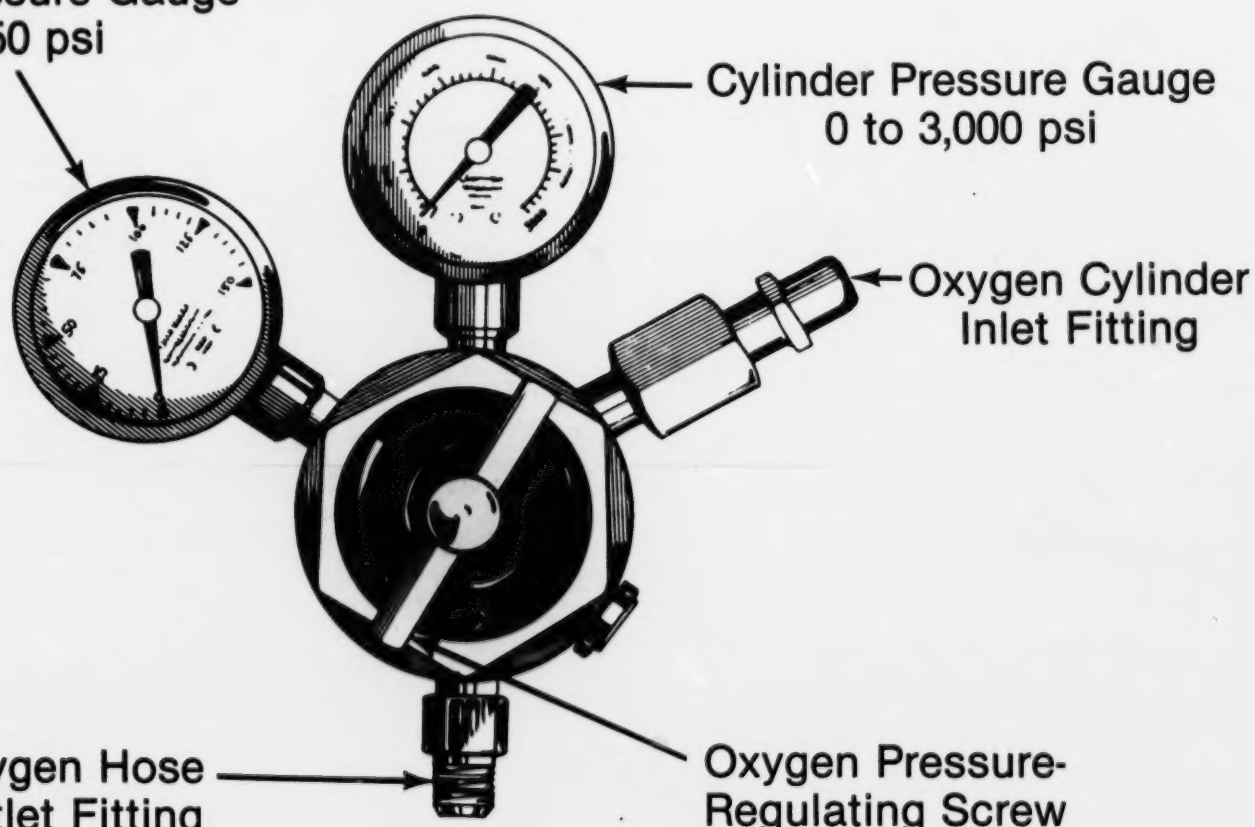
A. Althouse, Andrew P., Carl H. Turnquist, and William A. Bowditch. *Modern Welding*. Homewood, Illinois; Goodheart-Willcox Company, 1965.

B. Hendrix, Laborn J., "Bud" *Heavy Equipment Mechanic*. Stillwater, Oklahoma: State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center, and The Associated General Contractors of America, 1984.

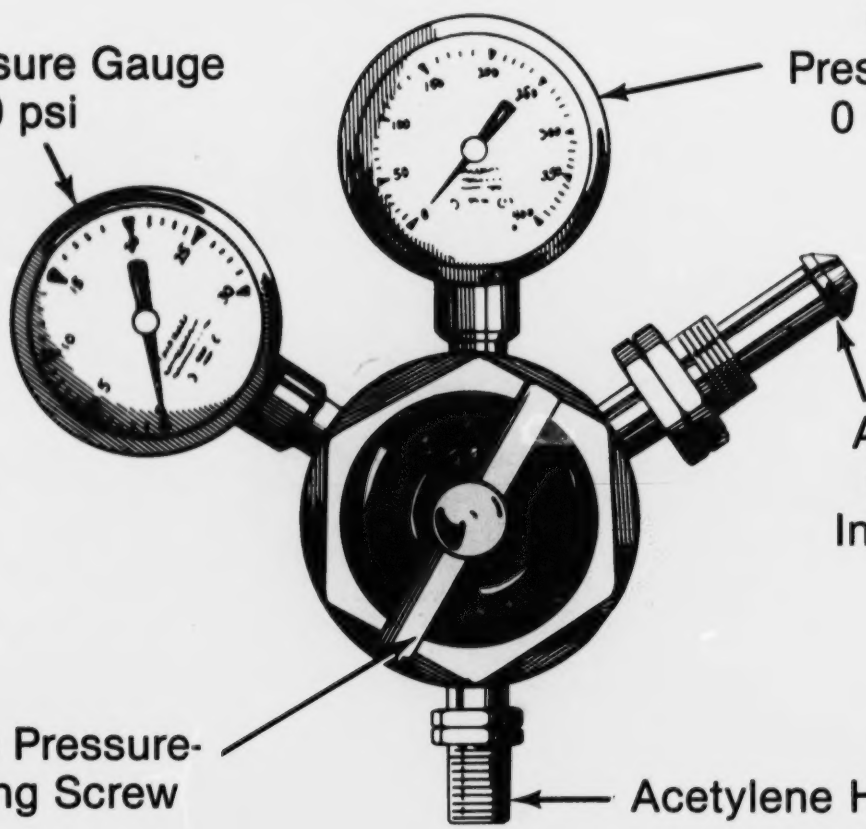
C. Hendrix, Laborn J., "Bud" *Millwright*. Stillwater, Oklahoma: State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center, and The Associated General Contractors of America, 1980.

D. Hendrix, Laborn J., "Bud." *Commercial Carpentry*. Stillwater, Oklahoma: State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center, and The Associated General Contractors of America, 1986.

Oxygen Regulator Gauges



Acetylene Regulator Gauges



TM #2

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OXYACETYLENE CUTTING
UNIT IV

INFORMATION SHEET

I. Terms and definitions associated with oxyacetylene cutting

A. **Acetylene** — Colorless, gaseous hydrocarbon used in cutting and welding

(NOTE: Other gases are also used in cutting.)

B. **Oxygen** — Element that is normally a colorless, odorless, and tasteless gas; used in combination with other substances in cutting and welding

C. **Oxyacetylene cutting** — Flame cutting of metal in which the preheating of the metal is accomplished with a flame produced by an oxyacetylene torch

D. **Purge** — To remove any foreign material from a system or component by flushing with the gas used in that system

E. **psi** — Pounds per square inch

F. **Combustible** — Capable of burning

G. **Toxic** — Poisonous

H. **Flint lighter** — Striker used to ignite torch

I. **Slag box** — Metal container with a layer of water or sand to catch hot material

J. **Slag** — Metal that melts away during the oxyacetylene cutting process

K. **Seizing** — Firmly binding cable with soft iron wire

II. Color codes for oxygen and acetylene

A. Oxygen — Green

B. Acetylene — Red

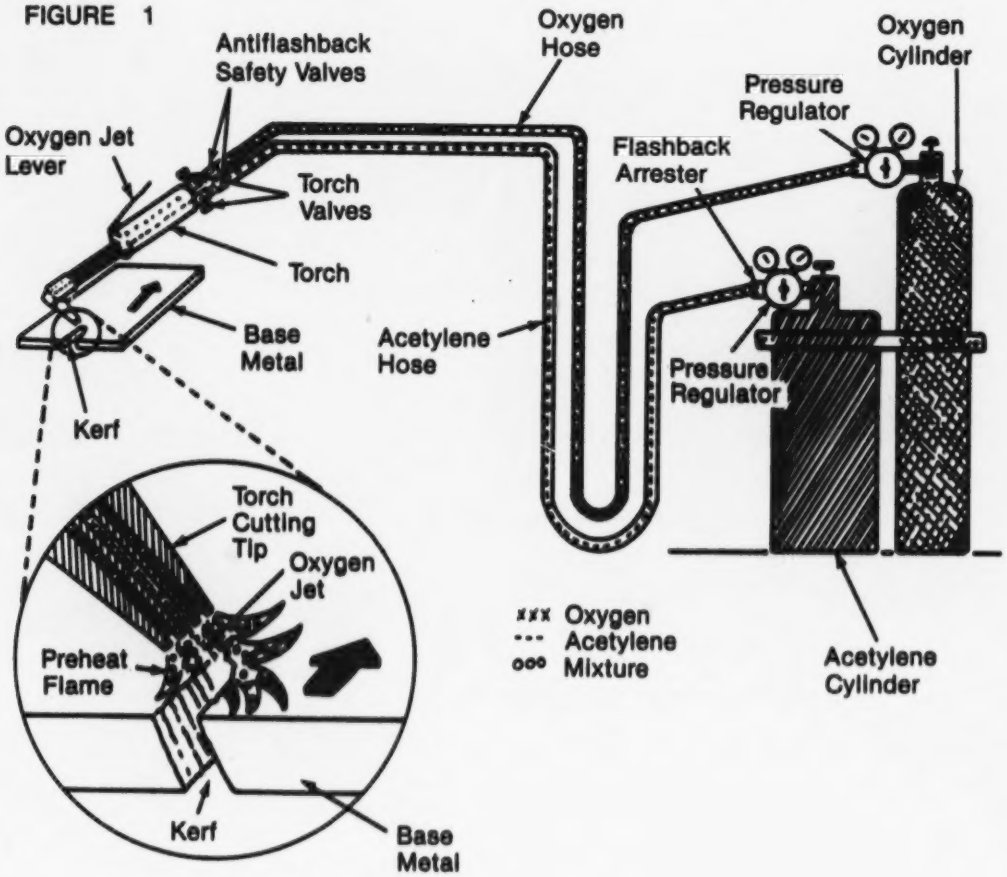
III. Stages in the oxyacetylene cutting process (Figure 1)

(NOTE: A flame of oxygen mixed with acetylene [or other gas] heats the base metal; then an oxygen jet cuts the heated metal. Oxyacetylene cutting is one of the most popular methods of cutting and shaping steel.)

INFORMATION SHEET

EXAMPLE:

FIGURE 1



A. Pressure-regulated acetylene and pressure-regulated compressed oxygen are supplied from two cylinders

(NOTE: Each cylinder has two pressure gauges. The cylinder pressure gauge indicates pressure in the cylinder [high], and the working pressure gauge indicates the pressure of the gas being fed to the torch [low].)

B. Separate, flexible hoses carry gases to torch

(NOTE: Two needle valves control the flow of gas.)

C. Operator ignites acetylene gas with spark from flint lighter

INFORMATION SHEET

D. Operator opens oxygen torch valve, and gases are mixed inside torch

E. Mixture burns at several orifices (preheat orifices) in torch tip

F. Flame heats base metal to a dull, cherry red

G. Operator presses oxygen lever, and jet of oxygen rushes out of cutting orifice

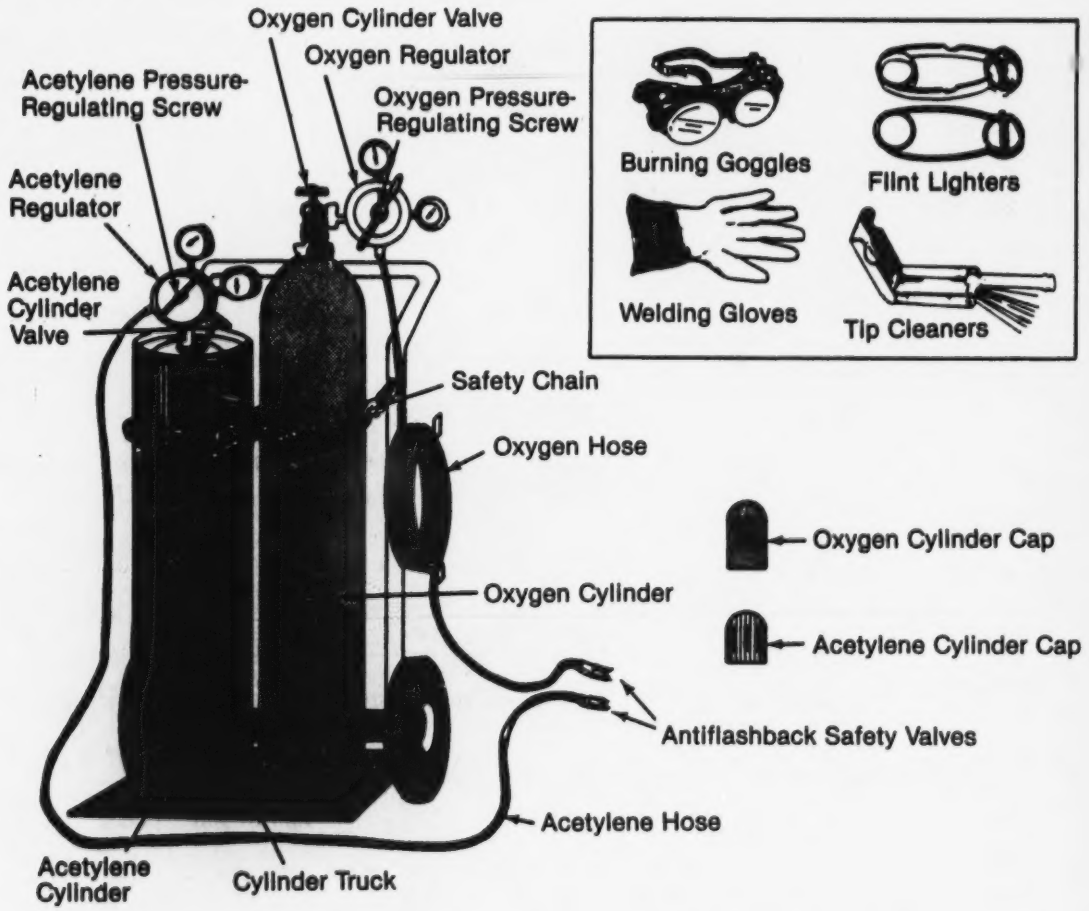
H. Oxygen jet quickly oxidizes the heated base metal and blows it away

I. Removal of material leaves a cut in the metal

IV. Parts of an oxyacetylene cutting outfit (Figure 2)

(NOTE: As an added safety feature, antiflashback valves between regulator and torch are required.)

FIGURE 2

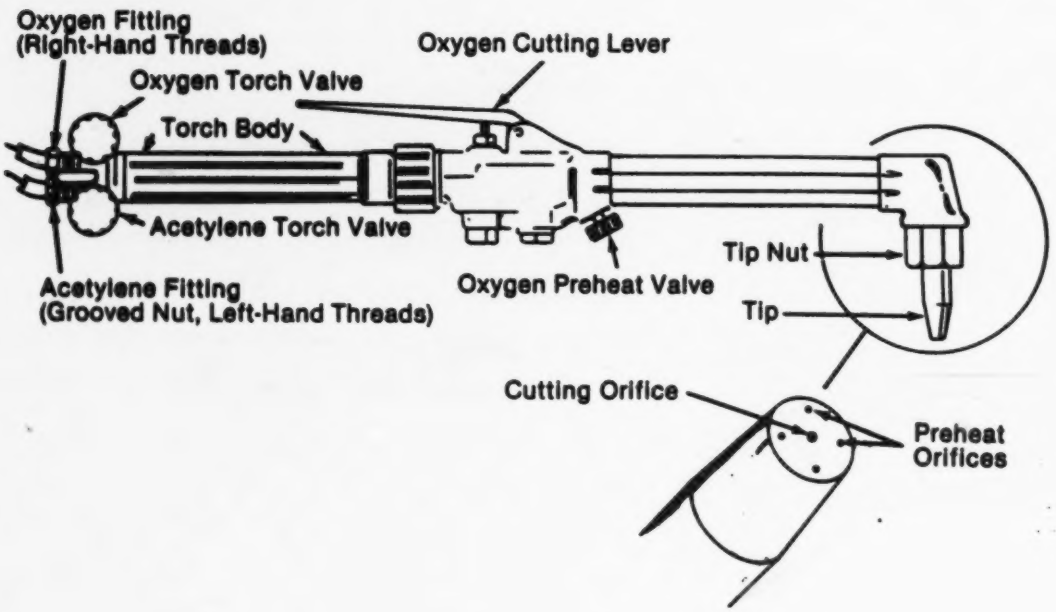


INFORMATION SHEET

V. Parts of a torch body and cutting attachment (Figure 3)

(NOTE: The preheat orifices heat metal to a kindling point of approximately 1,600°F [755°C]. The cutting orifice removes oxidized metal.)

FIGURE 3



VI. Safety rules for working with oxyacetylene equipment

(NOTE: Instructor may add other safety rules. The chief dangers of oxyacetylene cutting are burns and toxic fumes. Pay attention at all times, and notice how you feel.)

CAUTION

If you feel dizzy or nauseated or if you have blurred vision, stop cutting and get some fresh air.

A. Make sure that either foam or a multipurpose dry-chemical fire extinguisher is readily available and in working condition

B. Wear burning goggles, gloves, and protective clothing

CAUTION

Keep gloves, hands, and clothing free of oil and grease.

INFORMATION SHEET

C. Wear gloves to handle hot metal

D. Use open torch only in a well-ventilated place

E. Avoid breathing toxic fumes

EXAMPLES: Galvanized metal fumes, some paint fumes

F. Do not leave a burning torch unattended

G. Secure cylinders in a safe place

(NOTE: Secure cylinders to protect valves and regulators and to prevent injuries.)

H. Cut or weld at least 5 feet from cylinders

I. Always use regulators; do not use oxygen or acetylene directly from cylinders

(NOTE: Be sure that regulators are used only on the cylinders that they were designed to be used on.)

J. Use flint lighters, not matches, for lighting torch

K. Use hoses designated for oxygen and acetylene only

L. Do not use oil on regulators, torches, fittings, or any equipment surface that may come in contact with oxygen

CAUTION

Never oil or grease oxygen fittings. Substances will ignite with a violent explosion.

M. Do not use compressed oxygen to clean off clothing

CAUTION

Do not confuse compressed oxygen with compressed air. Oxygen speeds up combustion, and oxygen-soaked clothing needs only a spark to burst into flame.

N. Do not breathe compressed oxygen directly from cylinder or hose

O. Use soapsuds and paintbrush to test connections for leaks

P. Do not use acetylene at pressures higher than 15 pounds per square inch

CAUTION

Acetylene becomes unstable and highly explosive when pressure is over 15 psi.

INFORMATION SHEET

Q. Do not cut or weld directly on gravel or concrete

R. Keep heat, flames, and sparks away from combustibles

S. Do not cut or weld on containers that have been used to store combustible materials unless containers have been properly cleaned and purged

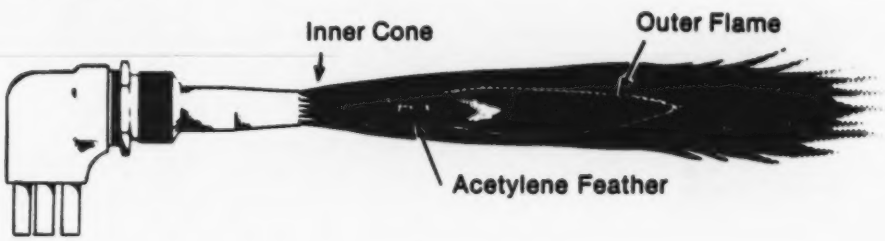
EXAMPLES: Containers that have held gases such as nitrogen, carbon dioxide, or argon

VII. Types of oxyacetylene cutting flames (Figures 4-6)

A. Carburizing flame

(NOTE: The flame illustrated has an excess of acetylene gas.)

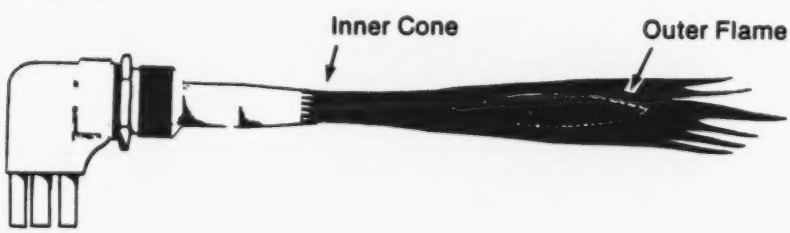
FIGURE 4



B. Neutral flame

(NOTE: The flame illustrated has the proper ratio of oxygen to acetylene.)

FIGURE 5

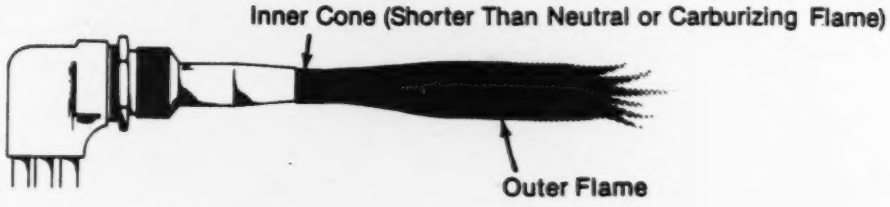


INFORMATION SHEET

C. Oxidizing flame

(NOTE: The flame illustrated has an excess of oxygen.)

FIGURE 6



VIII. Differences between flashback and backfire

A. Flashback — Flame disappears inside torch body; at the same time, a squealing noise occurs and smoke and/or sparks are emitted from the torch tip

B. Backfire — Flame burns momentarily back into tip; then a loud snap or pop is emitted from the torch and the flame either goes out or continues to burn in a normal manner

IX. Steps to follow in case of flashback

A. Close oxygen preheat valve

B. Close oxygen torch valve

C. Close acetylene torch valve

D. Release pressure on oxygen pressure-regulating screw

E. Release pressure on acetylene pressure-regulating screw

F. Examine acetylene unit

G. Reset regulator pressures

H. Light torch

(NOTE: If heavy smoke comes out of the torch tip and the torch body becomes hot, the flashback has probably traveled past the mixing chamber into the hose. In this case, shut off the oxygen and acetylene cylinder, and then notify the supervisor.)

INFORMATION SHEET

X. Causes of backfire

(NOTE: The causes listed below should be carefully checked to control backfire.)

A. Not enough acetylene or oxygen pressure for the tip size used

B. Loose cutting tip

C. Dirty tip

(NOTE: Tip may have deposits or metal particles inside orifice. These deposits may overheat and act as ignitors.)

D. Overheating of cutting tip

E. Bad O-ring in torch body

XI. Common cutting-torch tips and their uses (Figures 7-17)

(NOTE: Most of the following cutting tips are available in two or more sizes and should be selected on the basis of the thickness of the metal to be cut and the job to be performed.)

A. Straight-line or circular cutting of clean plate

FIGURE 7

B. Splitting angle iron, trimming plate, and cutting sheet metal

FIGURE 8

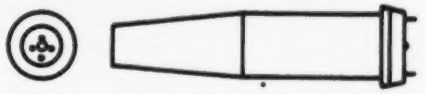
C. Hand cutting rivet heads; machine cutting 30-degree bevels

FIGURE 9

INFORMATION SHEET

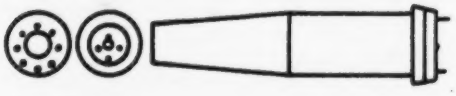
D. Straight-line or shape cutting of clean plate

FIGURE 10



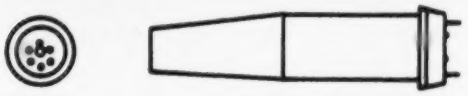
E. Cutting rusty or painted surfaces

FIGURE 11



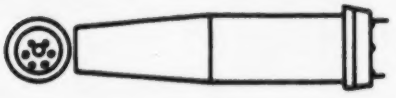
F. Cast-Iron cutting and preparing welding Vs

FIGURE 12



G. General cutting; cutting cast iron and stainless steel

FIGURE 13



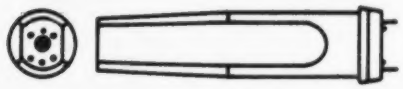
H. Grooving, flame machining, gouging, and removing imperfect welds

FIGURE 14

INFORMATION SHEET

I. Grooving, gouging, or removing imperfect welds

FIGURE 15



J. Machine cutting 45-degree bevels or hand cutting rivet heads

FIGURE 16

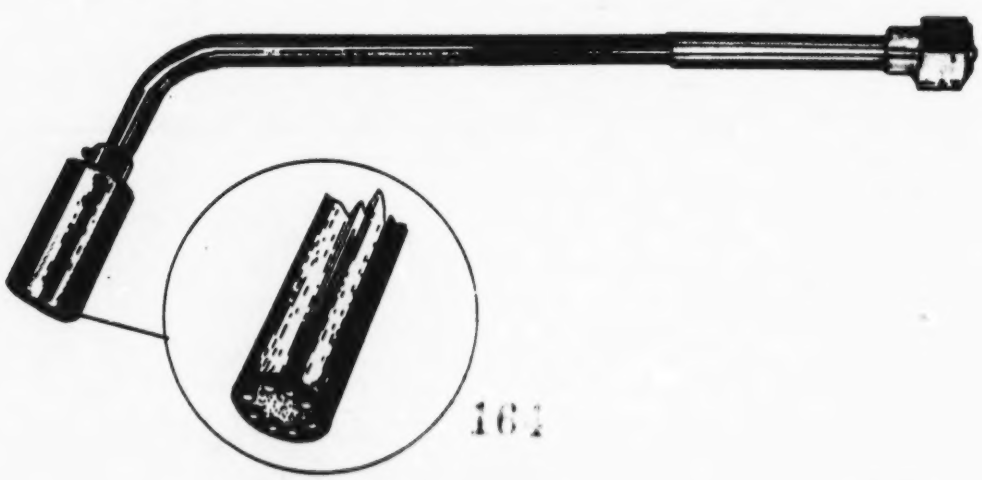
K. Removing rivet heads (washing)

(NOTE: Flared cutting orifices provide oxygen stream of low velocity.)

FIGURE 17

XII. Multiflame heating nozzle (rosebud) and tip (Figure 18)

FIGURE 18



INFORMATION SHEET

XIII. Uses of a multiflame heating nozzle (rosebud) — Used to heat parts or metals before fitting them together; also used to preheat metal before welding

XIV. Temperature sticks (temp-sticks) (Figure 19)

(NOTE: Temp-sticks come in a variety of colors but this has nothing to do with the heat range.)

FIGURE 19

XV. Selection and use of temperature sticks (temp-sticks)

A. Selection

1. Temperature sticks come in a wide variety for different temperatures
2. The proper temperature stick is determined by the type of metal or part being used or by the specifications

EXAMPLES: Bearings — 800°

Preheat before welding — 500°

B. Use

1. Used during the heating process
2. Mark dissipates when the metal or part has reached the proper temperature

OXYACETYLENE CUTTING
UNIT IV

JOB SHEET #1 — SET UP EQUIPMENT FOR OXYACETYLENE CUTTING

I. Equipment and materials

A. Oxygen cylinder

B. Acetylene cylinder

C. Oxygen regulator

D. Acetylene regulator

E. Hoses

F. Wrench

G. Cylinder truck

H. Foam or multipurpose dry-chemical fire extinguisher

I. Soapsuds

(NOTE: Ivory Soap is recommended for making soapsuds.)

J. Clean paintbrush

K. Torch body with tips

L. Burning goggles

M. Coveralls or protective clothing free of oil, grease, and frays

II. Procedure

A. Fasten cylinders in a vertical position on cylinder truck

CAUTION

To prevent damage to valves, never use acetylene from a cylinder that is not in a vertical position. Valve damage might cause cylinder to explode.

B. Remove caps from cylinders

C. Crack valves of each cylinder to remove foreign material; close valves

D. Connect oxygen regulator to oxygen cylinder

CAUTION

Do not use oil or any thread compound on any connections in the oxyacetylene system.

JOB SHEET #1

1. Turn oxygen pressure-regulating screw counterclockwise until tension on spring is released

2. Turn cylinder valve wide open slowly

E. Connect acetylene regulator to acetylene cylinder

1. Turn acetylene pressure-regulating screw counterclockwise until tension on spring is released

2. Open cylinder valve one-half to three-quarters of a turn

(NOTE: Never open cylinder valve more than one and one-half turns. Leave wrench with cylinder.)

F. Connect acetylene hose to acetylene regulator; purge hose

G. Connect oxygen hose to oxygen regulator; purge hose

H. Connect torch body to oxygen and acetylene hoses

I. Close both valves on torch body

J. Attach cutting attachment to torch body

(NOTE: The tip size is determined by the thickness of metal to be cut and the manufacturer's instructions.)

K. Close oxygen preheat valve on cutting attachment

L. Turn oxygen pressure-regulating screw clockwise until working pressure is reached

M. Turn acetylene pressure-regulating screw clockwise until correct working pressure is reached

CAUTION

At pressure higher than 15 psi, acetylene becomes unstable and highly explosive.

N. Use soapsuds to test all connections for leaks

(NOTE: Apply soapsuds with a clean paintbrush.)

O. Close regulator valves

P. Proceed to Job Sheet #2

OXYACETYLENE CUTTING
UNIT IV

JOB SHEET #2 — TURN ON, LIGHT, ADJUST TO A NEUTRAL FLAME, AND TURN OFF OXYACETYLENE CUTTING EQUIPMENT

I. Equipment and materials

A. Oxyacetylene cutting outfit with tip assembly

B. Wrench

C. Welding gloves

D. Burning goggles

E. Coveralls or protective clothing free of oil, grease, and frays

F. Flint lighter

G. Foam or multipurpose dry-chemical fire extinguisher

H. Tip cleaners

II. Procedure

A. Check all cylinder, regulator, and torch valves to make sure that they are closed

B. Open acetylene cylinder valve one-half to three-quarters of a turn

CAUTION

Never open cylinder valve more than one and one-half turns.

C. Open acetylene valve on torch one turn

D. Turn acetylene pressure-regulating screw clockwise until desired pressure is reached

(NOTE: Oxygen and acetylene pressures and size of tip depend upon the thickness of metal to be cut. Use pressures and tip size recommended by manufacturer.)

CAUTION

Acetylene becomes unstable and highly explosive at pressures higher than 15 psi.

E. Close acetylene valve on torch

F. Open oxygen cylinder valve all the way

JOB SHEET #2

G. Open oxygen torch valve all the way

H. Open oxygen preheat valve on cutting attachment one turn

I. Turn oxygen pressure-regulating screw clockwise until desired pressure is reached

J. Close oxygen preheat valve on cutting attachment

K. Open acetylene valve on torch one-quarter turn

L. Clean tip

(NOTE: Clean tip before lighting torch and as often as needed.)

M. Light torch with flint lighter and adjust until smoke on flame clears

N. Open oxygen preheat valve slowly and adjust to a neutral flame

O. Depress oxygen cutting lever, and check to see that a neutral flame is present

(NOTE: If necessary, adjust the oxygen preheat valve with the oxygen cutting lever depressed until a neutral flame is secured. Pressure rises slightly when valve is closed.)

P. Close acetylene valve on torch

Q. Close acetylene cylinder valve

R. Close oxygen preheat valve

S. Close oxygen cylinder valve

T. Open acetylene valve on torch

(NOTE: When gauges reach zero, close torch valve and release acetylene pressure-regulating screw by turning counterclockwise.)

U. Open oxygen preheat valve on torch

(NOTE: When gauges reach zero, close oxygen preheat valve and turn oxygen pressure-regulating screw counterclockwise.)

V. Close oxygen valve on torch

W. Place torch and hose on hanger or brackets provided

(NOTE: If regulators are removed from cylinders, replace the caps.)

X. Clean work area; clean and put away all tools and equipment

OXYACETYLENE CUTTING
UNIT IV

JOB SHEET #3 — CUT MILD STEEL AT A 90-DEGREE ANGLE, STOP, AND RESTART THE CUT

I. Equipment and materials

A. Oxyacetylene cutting outfit with tip assembly

B. Mild steel plate, approximately 1/4"×4"×8"

C. Soapstone with a sharp point or edge

D. Straightedge

E. Welding gloves

F. Burning goggles

G. Pliers

H. Coveralls or protective clothing free of oil, grease, and frays

I. Flint lighter

J. Welding or cutting table

K. Slag box

L. Can of water

M. Cutting tip

N. Foam or multipurpose dry-chemical fire extinguisher

O. Tip cleaners

II. Procedure

(NOTE: Follow procedure in Job Sheet #2, steps A through O, to turn on equipment.)

A. Make a 90-degree cut

1. Mark three parallel lines 2 inches apart on plate to be cut (see Figure 20)
2. Adjust oxygen regulator
3. Adjust acetylene regulator
4. Place plate to be cut over slag box

JOB SHEET #3

5. Clean tip

   (NOTE: Clean tip before lighting torch and as often as needed.)

6. Light torch with flint lighter

7. Adjust to neutral flame

8. Place hoses behind you

9. Assume comfortable position

10. Maneuver torch as required

    (NOTE: Sometimes you must use both hands to hold torch steady for a straight cut.)

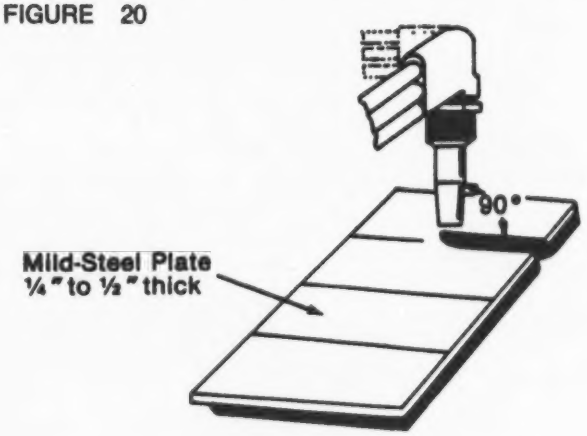
11. Hold preheat flame with tip of inner cone 1/16 to 1/8 inch above top of plate at right edge until red spot appears

> **CAUTION**
>
> Burning metal flames and sometimes sparks, creating the danger of burns.

12. Depress oxygen cutting lever and move from right to left across the plate (Figure 20)

    (NOTE: Left-handed operators move from left to right.)

FIGURE 20



JOB SHEET #3

13. Hold tip at right angle to work, while cutting with inner cone approximately 1/16 inch above work

14. Make 90-degree cuts until you have developed the proper procedure

15. Cool metal by placing in can of water with the aid of pliers

B. Restart a cut

1. Release oxygen cutting lever

2. Preheat only the edge where cutting action was stopped

3. Depress oxygen cutting lever slowly and continue cut

(NOTE: Follow procedure in Job Sheet #2, steps P through W, to turn off equipment.)

C. Clean work area; clean and put away all tools and equipment

OXYACETYLENE CUTTING
UNIT IV

JOB SHEET #4 — CUT ROUND STOCK

I. Equipment and materials

A. Oxyacetylene cutting outfit with tip assembly

B. Pieces of reinforcing bar, 1/2-inch, 5/8-inch, 3/4-inch, or 1-inch

C. Soapstone with sharp point or edge

D. Tape

E. Welding gloves

F. Burning goggles

G. Pliers

H. Coveralls or protective clothing free from oil, grease, and frays

I. Flint lighter

J. Welding or cutting table

K. Slag box

L. Can of water

M. Cutting tip

N. Foam or multipurpose dry-chemical fire extinguisher

O. Tip cleaners

II. Procedure

(NOTE: Follow procedure in Job Sheet #2, steps A through O, to turn on equipment.)

A. Mark reinforcing bar at desired length

B. Adjust oxygen and acetylene regulators

C. Place bar to be cut over slag box

D. Clean tip

(NOTE: Clean tip before lighting torch and as often as needed.)

JOB SHEET #4

E. Light torch with flint lighter

F. Adjust to neutral flame

G. Place hoses behind you

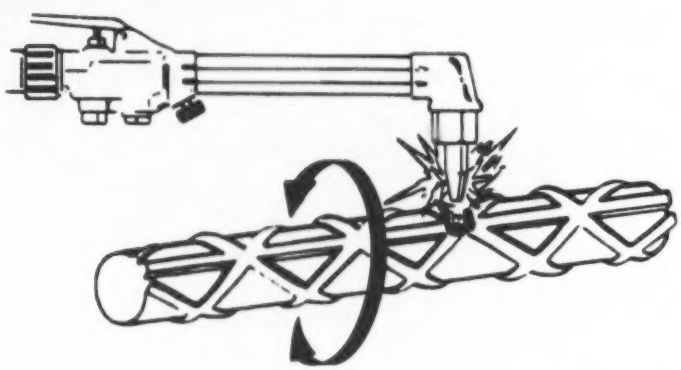
H. Assume comfortable position

I. Maneuver torch as required

J. Hold preheat flame with tip of inner cone 1/16 to 1/8 inch above edge of reinforcing bar until is becomes red

K. Depress cutting lever, and rotate torch in direction of travel until rod is cut (Figure 21)

FIGURE 21



L. Hold tip at right angle to work, while cutting with inner cone approximately 1/16 inch above work

M. Cool metal by placing in can of water with the aid of pliers

N. Repeat procedure for each bar or rod

(NOTE: Follow procedure in Job Sheet #2, steps P through W, to turn off equipment.)

O. Clean work area; clean and put away all tools and equipment

OXYACETYLENE CUTTING
UNIT IV

JOB SHEET #5 — CUT CABLE

I. Equipment and materials

A. Oxyacetylene cutting outfit with tip assembly

B. Cutting tip

C. Flint lighter

D. Piece of cable

E. Soapstone with sharp point or edge

F. Welding gloves

G. Burning goggles

H. Can of water

I. Foam or multipurpose dry-chemical fire extinguisher

J. Coveralls or protective clothing free from oil, grease, and frays

K. Tip cleaners

II. Procedure

(NOTE: Follow procedure in Job Sheet #2, steps A through O, to turn on equipment.)

A. Place fire extinguisher near work area

B. Determine where cable is to be cut; mark with soapstone

C. Adjust oxygen and acetylene regulators

D. Clean tip

(NOTE: Clean tip before lighting torch and as often as needed.)

E. Light torch with flint lighter

F. Adjust to neutral flame

G. Place hoses behind you

H. Assume comfortable position

JOB SHEET #5

I. Maneuver torch as required

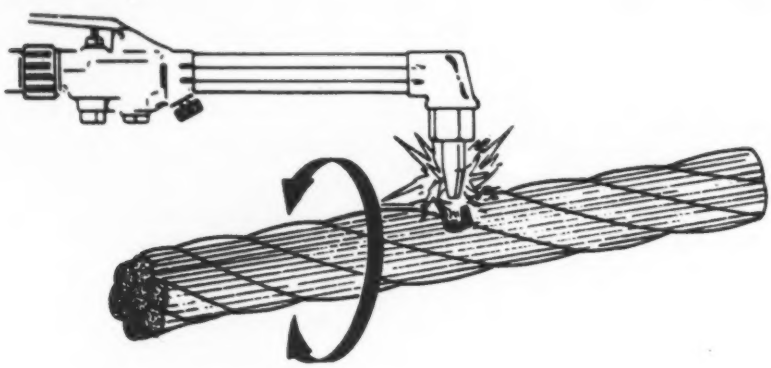
CAUTION

If there is tension on the cable, take care to avoid flying loose ends when the cable is cut. These ends can be very dangerous.

J. Hold preheat flame with tip of inner cone 1/16 to 1/8 inch above edge of cable until it becomes red

K. Depress cutting lever, and rotate torch in direction of travel until cable is cut (Figure 22)

FIGURE 22



L. Hold tip at right angle to work while cutting with inner cone approximately 1/16 inch above work

M. Cool metal by pouring water over hot ends

N. Repeat procedure for each cut

(NOTE: This is a very good method to use on all types of cable as it is quick and easy and will weld the ends, thus reducing strain on the seizing and preventing raveling. Follow procedure in Job Sheet #2, steps P through W, to turn off equipment.)

O. Clean work area; clean and put away all tools and equipment

OXYACETYLENE CUTTING
UNIT IV

TEST

NAME _____ SCORE _____

1. Match to their correct definitions terms associated with oxyacetylene cutting. Write the correct numbers in the blanks.

_____a. Colorless, gaseous hydrocarbon used in cutting and welding	1. Toxic
_____b. Element that is normally a colorless, odorless, and tasteless gas; used in combination with other substances in cutting and welding	2. Purge
_____c. Flame cutting of metal in which the preheating of the metal is accomplished with a flame produced by an oxyacetylene torch	3. Oxygen
_____d. To remove any foreign material from a system or component by flushing with the gas used in that system	4. Combustible
_____e. Pounds per square inch	5. Oxyacetylene cutting
_____f. Capable of burning	6. psi
_____g. Poisonous	7. Acetylene
_____h. Striker used to ignite torch	8. Seizing
_____i. Metal container with a layer of water or sand to catch hot material	9. Flint lighter
_____j. Metal that melts away during the oxyacetylene cutting process	10. Slag box
_____k. Firmly binding cable with soft iron wire	11. Slag

2. State color codes for oxygen and acetylene.

   a. Oxygen — _____

   b. Acetylene — _____

TEST

3. Arrange in order stages in the oxyacetylene cutting process. Write a "1" before the first step, a "2" before the second step, and so on.

_____a. Mixture burns at several orifices (preheat orifices) in torch tip

_____b. Oxygen jet quickly oxidizes the heated base metal and blows it away

_____c. Separate, flexible hoses carry gases to torch

_____d. Flame heats base metal to a dull, cherry red

_____e. Pressure-regulated acetylene and pressure-regulated compressed oxygen are supplied from two cylinders

_____f. Removal of material leaves a cut in the metal

_____g. Operator ignites acetylene gas with spark from flint lighter

_____h. Operator presses oxygen lever, and jet of oxygen rushes out of cutting orifice

_____i. Operator opens oxygen torch valve, and gases are mixed inside torch

TEST

4. Identify the parts of an oxyacetylene cutting outfit. Write the correct numbers in the blanks.

_____a. Oxygen hose

_____b. Oxygen cylinder valve

_____c. Acetylene hose

_____d. Acetylene cylinder cap

_____e. Welding gloves

_____f. Oxygen cylinder

_____g. Acetylene cylinder

_____h. Acetylene regulator

_____i. Acetylene pressure-regulating screw

_____j. Flint lighters

_____k. Oxygen cylinder cap

_____l. Safety chain

_____m. Burning goggles

_____n. Acetylene cylinder valve

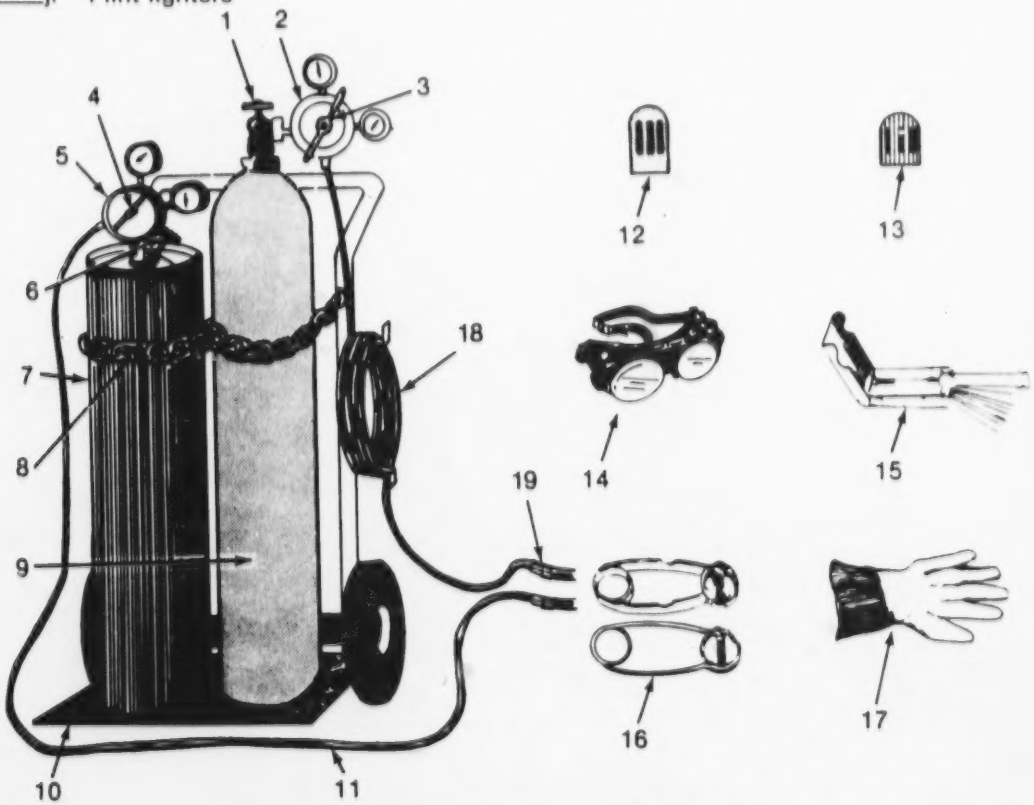
_____o. Oxygen pressure-regulating screw

_____p. Tip cleaners

_____q. Oxygen regulator

_____r. Antiflashback safety valve

_____s. Cylinder truck



TEST

5. Identify the parts of a torch body and cutting attachment. Write the correct numbers in the blanks.

_____a. Acetylene fitting (grooved nut, left-hand threads)

_____b. Cutting orifice

_____c. Oxygen fitting (right-hand threads)

_____d. Tip nut

_____e. Oxygen preheat valve

_____f. Preheat orifices

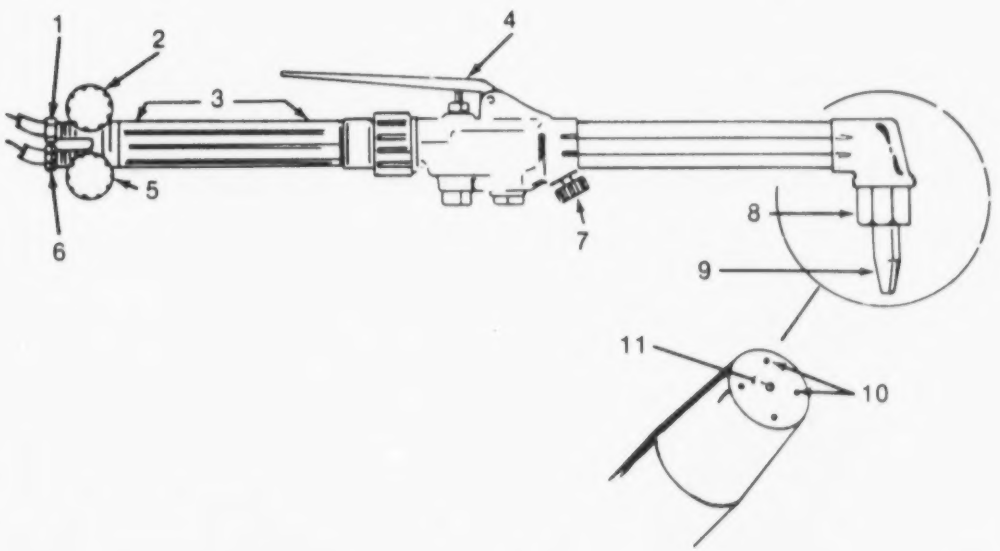
_____g. Oxygen torch valve

_____h. Tip

_____i. Oxygen cutting lever

_____j. Torch body

_____k. Acetylene torch valve



6. State twelve safety rules for working with oxyacetylene equipment.

a. _____

b. _____

c. _____

d. _____

TEST

e. _____

f. _____

g. _____

h. _____

i. _____

j. _____

k. _____

l. _____

7. Identify the following types of oxyacetylene cutting flames. Write the correct names in the blanks.

Neutral flame **Oxidizing flame** **Carburizing flame**

a. _____

b. _____

c. _____

TEST

8. Distinguish between flashback and backfire. Write an "F" in the blank before flashback and a "B" in the blank before backfire.

_____a. Flame burns momentarily back into tip; then a loud snap or pop is emitted from the torch and the flame either goes out or continues to burn in a normal manner

_____b. Flame disappears inside torch body; at the same time, a squealing noise occurs and smoke and/or sparks are emitted from the torch tip

9. Arrange in order steps to follow in case of flashback. Write a "1" before the first step, a "2" before the second step, and so on.

_____a. Light torch

_____b. Release oxygen pressure-regulating screw

_____c. Reset regulator pressures

_____d. Close oxygen torch valve

_____e. Close oxygen preheat valve

_____f. Release acetylene pressure-regulating screw

_____g. Close acetylene torch valve

_____h. Examine acetylene unit

10. Select from the following list causes of backfire. Write an "X" in the blank before each correct answer.

_____a. Too much oxygen

_____b. Not enough acetylene or oxygen pressure for the tip size used

_____c. Too much acetylene

_____d. Loose cutting tip

_____e. Overheating of cutting tip

_____f. Bad O-ring in torch body

_____g. Dirty tip

TEST

11. Match to their correct uses common cutting-torch tips. Write the correct numbers in the blanks.

_____a. Machine cutting 45-degree bevels or hand cutting rivet heads

_____b. Cast-iron cutting and preparing welding Vs

_____c. Splitting angle iron, trimming plate, and cutting sheet metal

_____d. General cutting; cutting cast iron and stainless steel

_____e. Grooving, gouging, or removing imperfect welds

_____f. Hand cutting rivet heads; machine cutting 30-degree bevels

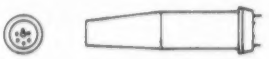
_____g. Straight-line or circular cutting of clean plate

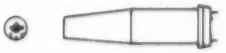
_____h. Cutting rusty or painted surfaces

_____i. Grooving, flame machining, gouging, and removing imperfect welds

_____j. Removing rivet heads (washing)

_____k. Straight-line or shape cutting of clean plate

1. 

2. 

3.

4.

5.

6.

7.

8.

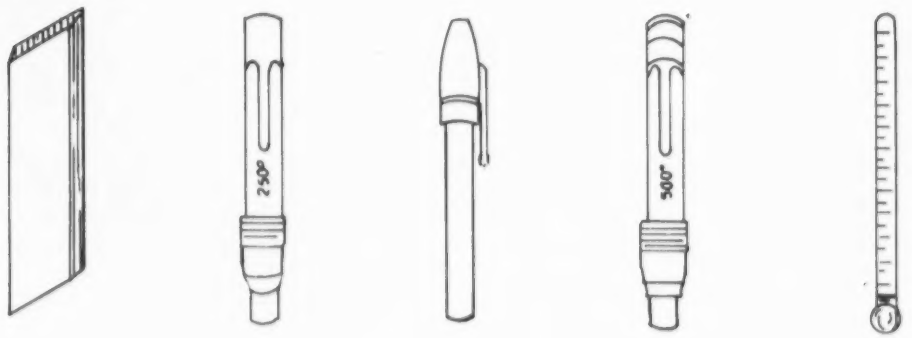
9.

10.

11.

TEST

14. Identify temperature sticks (temp-sticks) in the illustrations below by placing an "X" in the correct blanks.



a. _____ b. _____ c. _____ d. _____ e. _____

15. Describe the selection and use of temperature sticks (temp-sticks).

a. Selection

1) _____

2) _____

b. Use

1) _____

2) _____

(NOTE: Test question 16 lists the job sheets. They are an important part of this test. If they have not been completed, check with your instructor.)

16. Demonstrate the ability to

a. Set up equipment for oxyacetylene cutting.

b. Turn on, light, adjust to a neutral flame, and turn off oxyacetylene cutting equipment.

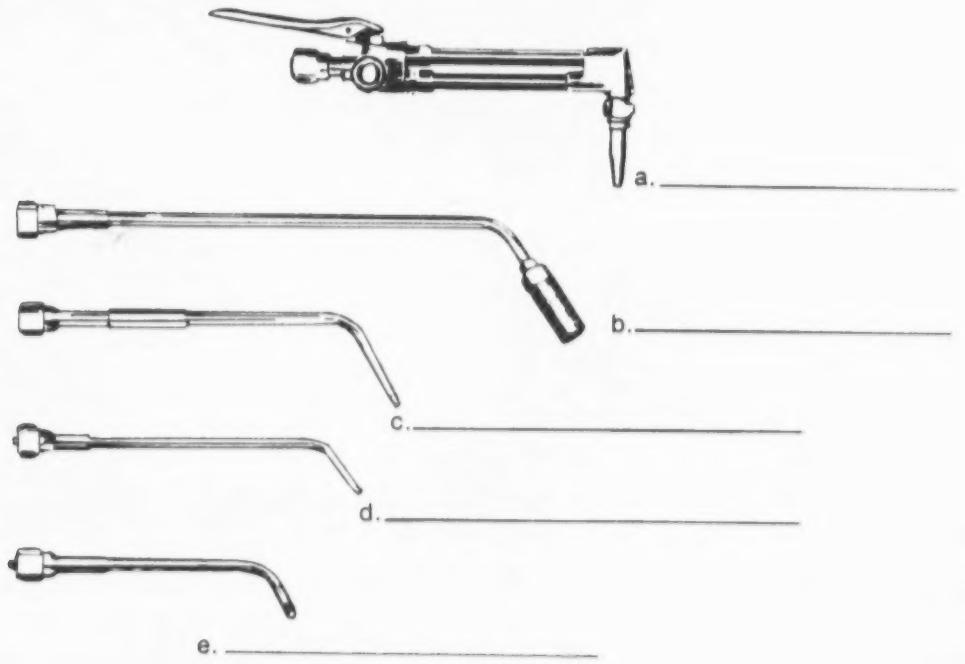
c. Cut mild steel at a 90-degree angle, stop, and restart the cut.

d. Cut round stock.

e. Cut cable.

TEST

12. Identify a multiflame heating nozzle (rosebud) and tip from the illustrations below. Write an "X" in the blank beside the correct illustration.



13. Describe uses of a multiflame heating nozzle (rosebud).

_____

_____

_____

_____

OXYACETYLENE CUTTING
UNIT IV

ANSWERS TO TEST

1. a. 7 d. 2 g. 1 j. 11
   b. 3 e. 6 h. 9 k. 8
   c. 5 f. 4 i. 10

2. a. Green
   b. Red

3. a. 5 d. 6 g. 3
   b. 8 e. 1 h. 7
   c. 2 f. 9 i. 4

4. a. 18 f. 9 k. 12 p. 15
   b. 1 g. 7 l. 8 q. 2
   c. 11 h. 5 m. 14 r. 19
   d. 13 i. 4 n. 6 s. 10
   e. 17 j. 16 o. 3

5. a. 6 e. 7 i. 4
   b. 11 f. 10 j. 3
   c. 1 g. 2 k. 5
   d. 8 h. 9

6. Answer should include any twelve of the following

   a. Make sure that either a foam or a multipurpose dry-chemical fire extinguisher is readily available and in working condition
   b. Wear burning goggles, gloves, and protective clothing
   c. Wear gloves to handle hot metal
   d. Use open torch only in a well-ventilated place
   e. Avoid breathing toxic fumes
   f. Do not leave a burning torch unattended
   g. Secure cylinders in a safe place
   h. Cut or weld at least 5 feet from cylinders
   i. Always use regulators; do not use oxygen or acetylene directly from cylinders
   j. Use flint lighters, *not matches*, for lighting torch
   k. Use hoses designated for oxygen and acetylene only
   l. Do not use oil on regulators, torches, fittings, or any equipment surface that may come in contact with oxygen
   m. Do not use compressed oxygen to clean off clothing

ANSWERS TO TEST

n. Do not breathe compressed oxygen directly from cylinder or hose
o. Use soapsuds and paintbrush to test connections for leaks
p. Do not use acetylene at pressures higher than 15 pounds per square inch
q. Do not cut or weld directly on gravel or concrete
r. Keep heat, flames, and sparks away from combustibles
s. Do not cut or weld on containers that have been used to store combustible materials unless containers have been properly cleaned and purged

7. a. Oxidizing flame
   b. Carburizing flame
   c. Neutral flame

8. a. B
   b. F

9. a. 8
   b. 4
   c. 7
   d. 2
   e. 1
   f. 5
   g. 3
   h. 6

10. b, d, e, f, g

11. a. 6
    b. 1
    c. 5
    d. 9
    e. 4
    f. 8
    g. 3
    h. 7
    i. 10
    j. 2
    k. 11

12. b

13. Description should include the following — Used to heat parts or metals before fitting them together; also used to preheat metal before welding

14. b, d

15. a. Selection
    1) Temperature sticks come in a wide variety for different temperatures
    2) Proper temperature stick is determined by the type of metal or part being used or by the specifications

ANSWERS TO TEST

b. Use
   1) Used during the heating process
   2) Mark dissipates when the metal or part has reached the proper temperature

16. Performance skills evaluated to the satisfaction of the instructor